# A NATURALIST IN INDIAN SEAS

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## OR, FOUR YEARS WITH THE ROYAL INDIAN MARINE SURVEY SHIP "INVESTIGATOR"

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TO

MY OLD SHIPMATES

OF THE

*INVESTIGATOR*

# PREFACE

THIS little story of the deep, compiled from the records of the Royal Indian Marine Survey Ship *Investigator*, is, like a certain ancient territory of Lower School memories, divided into three parts.

The first part, the substance of most of which was written some years ago for the *Times of India*, is meant—now that I have hung up my *uvida vestamenta*—to be a sort of votive tablet of my own to those powerful deities of the sea who shipwrecked my prospects as a surgeon in order to make of me a naturalist, and to use me in their own affairs. In this part I have endeavoured to be as little technical as possible, so as to accommodate myself—if I may maintain good Master Corporate Bardolph's good and commendable phrase—to the general reader.

The second part is intended, at the approach of the twenty-first anniversary of her existence, to be a brief recital of the *Investigator's* maiden efforts in the field of natural history since she first drew water in the year of Our Lord 1881. In it I have still tried to make myself intelligible to readers who are not professed zoologists.

The third part, it must be frankly confessed, is of no interest but to students of marine zoology. It contains lists of the *Investigator* deep-sea dredging-stations, and of *Investigator* literature, of which it is desirable, and—for the reason above suggested—now specially appropriate to have a permanent record in a convenient form. Fortunately, or unfortunately, it is short.

I have elsewhere expressed the debt that I owe to Rear-Admiral Sir John Hext, R.N., K.C.I.E., formerly Director of the Royal Indian Marine, for the generous support that he always gave to the work of which this small volume is one of the by-products; and I have here to record my sincere acknowledgments to the present Director, Captain W. S. Goodridge, R.N., C.I.E., for kindly giving me permission to use some of the excellent drawings of the artist to the Marine Survey, Babu Shib Chunder Mondul, and his predecessor Babu Abhoya Charn Chowdry. I am also under multifarious obligations to my successors, Dr A. R. S. Anderson and Dr A. F. M'Ardle.

If, in conclusion, I explain that, although most of the personal experiences herein recorded are more than ten years old, the work of which they form a part is still in active progress, I trust I shall escape the charge, in these days of rapid development, of being in rear of the times.

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# PART I

## AN INTRODUCTION, AN EXPLANATION, AND A NARRATIVE

"παρεσκευασμένοι δὲ πάντα ἔπλεον, προσίσχοντες δὲ τὰ παραθαλάσσια ἐθηεῦντο καὶ ἀπεγραφοντο."

HEROD., *Hist.*, iii., 136.

## CHAPTER I

### INTRODUCTORY

"Forasmuch as the main ocean is the Lord's alone, and by nature left free for all men to deal withal, as very sufficient for all men's use, and large enough for all men's industry."

*Drake's Voyage.*

Prolegomena. The Origin of the Marine Survey of India. Earlier Marine Surveys in India. The Beginnings of the Exploration of Eastern Seas; Davis and Baffin; Drake. Present and Past, a Contrast.

One of the figures dearest to human fancy is the trilogy; so that I hope to make a happy beginning by saying that the seas of India, which I invite my readers casually to explore with me, are three, namely, the Arabian Sea, the Bay of Bengal, and the Andaman Sea.

Some say that, ages ago, before the appearance of man upon the earth, these seas were one with a great inland ocean, of which the present Mediterranean is the shrunken remains. Peninsular India and Ceylon then formed a great island-continent, connected by a chain of large islands—of some of which the Maldives and Chagos and Seychelles are the tombstones—with

Madagascar and South Africa, and separated from the present heart of Asia by a deep channel—a channel perhaps traversed, much as now the West Indies traverse the Caribbean, by a series of islands, which may have been lowly precursors of the Himalayas; for these gigantic mountains are of quite recent origin. Through this Himalayan channel the tides may have swept westwards into a northward extension of the Arabian Sea, and so on, through a wide-spread Mediterranean — a Mediterranean beneath whose waters all the ancient monarchies and all the origins of our civilisation lay, still undreamt-of—into the Atlantic, the condition of Asia Minor and of Middle and Southern Europe being then one of

"Universal Ocean, softly washing all her warless isles."

To my mind there is something very stirring in the thought that, somewhere near where now the Salt Range rises out of the silent Punjab desert, there may once have been heard the echoes of a sea whose currents perhaps—like an eastern Gulf Stream—carried warmth and comfort to northern latitudes, as if prophetic of a returning tide of civilisation in after ages.*

This, however, is merely speculation, and though such speculations may perhaps rouse the imagination,

* As to the possibility of currents from the Indian Ocean having benignly influenced arctic climates in Tertiary times in the way here suggested, see Wallace, *Island Life*, p. 186.

they form no part of the present modest story, which relates to some of the things that I myself learned about the seas of India in certain happy days when I was an officer in the Indian Marine Survey ship *Investigator*. But as all our knowledge, however local and esoteric, and all our methods of using it and increasing it, are but the outcome of the thought taken and the pains endured by our countless predecessors, it will not be amiss if, by way of introduction, I say a few words, not so much of those predecessors in the whole of this particular field, as of the local steps which—begun and continued by some of them—have, for the present, culminated in the local observations of the *Investigator*, some of which are herein described.

The Marine Survey of India began its existence under Commander Dundas Taylor in the year 1874. This was at the time when the discoveries of H.M.S. *Challenger* were opening out a new world to Science, and new prospects to marine surveyors. The new Survey Department was keenly alive to its responsibilities; but, unhappily, its means of meeting them were at first very imperfect, and it was not until the year 1881, when the *Investigator* was launched, that the newly-created department was able, in a small and restricted way, of course, to follow the signal given, with such lasting effect, by the *Challenger*. Before the advent of the *Investigator*, the work of the

Indian Marine Survey did not go very much beyond surveying the coasts for the actual necessities of navigation and commerce.

Though the *Investigator* and the present Marine Survey of India are quite modern institutions, the surveying of Indian waters is an old undertaking.* Between 1832 and 1862, when that service was abolished, many valuable marine surveys were executed by officers of the Indian Navy, whose bird's-eye view, like that of Little Billee on the maintopgallant mast, in Thackeray's ballad, almost literally ranged from Jerusalem to Madagascar. Indian naval surveyors carried on their operations from the upper reaches of the Tigris and Euphrates, and the ruins of Nineveh and Babylon, to the coral-reefs of the Seychelles; and it was one of these officers, Lieutenant John Wood, who discovered the sources of the Oxus.

But before the days of the Indian Navy, excellent surveys of eastern waters, from the Red Sea to China, had at various times been made by the officers of the Bombay Marine—an extinct service, out of which the Indian Navy was evolved in 1832. Among the surveying ships of this time was an old *Investigator*, long since broken up and, except that she gave her name to some obscure channels in the Mergui Archipelago, forgotten.

* See *A Memoir on the Indian Surveys*, by Sir Clements Markham, published by the Secretary of State for India.

Long before the Bombay Marine existed, however, and even before the old East India Company became a power in the land, the seas of India were being roughly and fitfully surveyed by English explorers. Some of the old sea-dogs of the spacious times of great Elizabeth carried their flag—it was the plain red cross of Saint George in those days — into eastern waters, and even coloured these waters with their life-blood. So we may learn that, viewed from a broad standpoint, little things, like a local branch of science, and great things, like an Indian Empire and the rule of the seas, all had their birth in one great impulse, and are phases of the same destiny.

The earliest of these great Elizabethans who left any sort of record of his Indian surveys was John Davis—that John Davis whose name is familiar to everyone in Davis' Strait between Greenland and America, and whose history is a part of our imperishable arctic annals. After again and again facing the perils of the unknown arctic ice, and after a disastrous attempt to reach the gorgeous East in the track discovered by Magellan, John Davis took to piloting voyages to India by the Cape route. The great navigator's last adventure proved fatal to him, for he was treacherously murdered by Malay pirates off the coast of Sumatra, and his bones were turned to coral in the reefs that beset the Singapore Strait, probably. I like to fancy that the eyes of John Davis took

bearings of those beautiful "Ilands of the Bay,"* where, nearly three hundred years later, so much of the *Investigator's* work was performed, and to think that John Davis' *Sailing Directions for the West Coast of Sumatra*, which may be found in Captain Markham's *Voyages and Works of John Davis*, published by the Hakluyt Society, are the earliest records of those surveys in the Bay of Bengal that the *Investigator* is still labouring to complete according to modern standards.

Another of the illustrious band of arctic pioneers whose destiny was accomplished in a voyage of exploration into Indian seas was William Baffin, whose name is enshrined, *monumentum aere perennius*, in Baffin-land and Baffin Bay, and whom Sir Clements Markham calls the first Indian marine surveyor. After several voyages to "the sea without a human shore," Baffin made two voyages to India, in the first of which he drew certain charts of the eastern seas which earned the commendation and reward of his employers. But the second ended tragically, for he was killed in action against the Portuguese, at the entrance to the Persian Gulf. "In the Indies he dyed, in the late Ormus businesse, slaine in fight with a shot, as hee was trying his mathematicall proiects and conclusions" to find the range of his guns. May his spirit be guarding those disputed

* Andaman Islands.

British interests in the Gulf which he laid down his life in defending.

If we may thus easily trace back the origin of the Indian Marine Survey to Davis and Baffin, we may without any great stretch of fancy go a step still further back, to a name of even greater lustre in our naval annals, for the very beginning of our subject. The immortal Drake, though he did not make any Indian landfall, yet, in the course of his famous voyage of circumnavigation, cruised for some little time in the eastern approaches to Indian waters, where, as if anticipating the modern idea of a marine surveyor, he unconsciously made a noteworthy contribution to zoology by discovering and pointing out the economic value of the great Robber Crab. Though Drake was not—as Davis and Baffin were—engaged in the early ventures of the East India Company, he may still be allowed a place in the background of British Indian History; for he exchanged state visits with some of the Rajahs of Java, and he entered into negotiations with the Sultan of Ternate in the Moluccas, and it was upon these latter modest diplomatic advances that, according to Corbett, our subsequent intervention in eastern affairs was for many years afterwards based.

I cannot regard this Introduction—which is meant to show, within the limits of my subject, some of the

uncertain stepping-stones that connect the present and the past—as complete, without contrasting the "holiday and lady terms" of the sea-survey service of the present scientific time with the rough, coarse, unhandsome life of the old explorers of those early days. The worst that I can remember of the *Investigator* was, that we had no ice for our liquor, and very little chance of doing harm to our wit by eating roast beef, and that sometimes we could get only one bucket of fresh water for our morning ablutions. Otherwise we lived as comfortably as people ashore; and though once we had rather too much of turtle, we were never reduced to eating the Robber Crab, which Drake and his brave men esteemed as a "very good and restorative meat," and a luxury to be spoken of with gratitude. Our most straitened voyage was one when the eggs that we brought away from port got beyond the stage in which they are still suitable for the manufacture of omelets.

Now let us consider the bill of fare of the famous Magellan, when, in the year 1521, he was approaching these seas. Says the chronicler of his wonderful voyage: *—

"We only ate old biscuit reduced to powder, and full of grubs, and stinking, and we drank water that was yellow and stinking. We also ate the ox-hides

* *First Voyage round the World by Magellan*, translated by Lord Stanley of Alderley, and published by the Hakluyt Society.

that were under the main-yard; they were very hard on account of the sun, rain, and wind, and we left them for four or five days in the sea, and then put them a little on the embers, and so ate them; also the sawdust of wood, and rats."

The good John Davis seems to have endured misery quite as great as this. In the course of one of his voyages the supply of water almost ran out:*—

"Our allowance of drinke, which was scant ynough before, was yet more scanted . . . so that now a man was allowed but halfe a pinte at a meale. From halfe a pinte we came to a quarter, and that lasted not long neither. With this hard fare (for by reason of our great want of drinke, wee durst eate but very litle) wee continued for the space of a fortnight or thereabouts, saving that now and then wee feasted, and that was when there fell any haile or raine, the hailestones wee gathered up, and did eat them more pleasantly than if they had bene the sweetest Comfits in the world. And that water which fell downe and washed away the filth and soyling of the shippe . . . was not lost, I warrant you, but watched and attended carefully (yea, sometimes with strife and contention) at every scupper-hole . . . notwithstanding it were muddie and bitter with washing the shippe, but (with

* This and the subsequent quotations are from *The Voyages and Works of John Davis*, edited by Captain A. H. Markham, and published by the Hakluyt Society.

some sugar, which we had to sweeten it withal) it went merrily downe."

Another time he ran short of food, and had to allowance his men on the following reduced scale:—

"Two ounces and a halfe of meale for a man a day, and to have so twise a weeke, so that five ounces did serve for a weeke. Three daies a weeke we had oile, three spoonfuls for a man a day, and two daies in a weeke peason, a pint between four men a day, and every day five Penguins for four men, and six quarters of water for four men a day. This was our allowance; wherewith (we praise God) we lived, though weakly and very feeble."

What the idea of comfort on board an exploring ship in those days was like is shown in a passage from an account of Davis' unsuccessful voyage of circumnavigation:—

"In this place we fared passing well with egs, Penguins, yong Seales, yong Gulles, besides other birds such as I know not; all of which we had in great abundance. In this place we found an herb called Scurvygrasse, which wee fried with egs, using traine oyle in stead of butter."

With possibilities of this sort ahead of them, it is not surprising that the old explorers and navigators prepared themselves for their voyages with a solemnity that is now quite out of fashion. They would ceremoniously cleanse themselves from all unrighteousness,

and would humbly implore that divine protection which we nowadays are inclined to take for granted. Thus, before "Martyne Frobysher, gent.," started to search for a north-west passage to Cathay, he secured the services of the Gravesend clergyman, who boarded the "tall ship" *Aid*, and "prepared us as good Christians toward God, and resolute men for all fortunes." Nor, on their return, did they forget to render thanks for the mercy which had preserved them: the first act of the survivors of Magellan's famous voyage was to attend, barefoot and in their shirts, a formal service of thanksgiving for their safe deliverance from the prolonged perils of the sea.

These are pretty pictures, but they are out of date in this twentieth century of the Christian era. The modern marine surveyor (whose risks, thanks to the stores of experience painfully accumulated by those who have gone before him, are reduced to a minimum) need not go to such extremes. He can show his pious appreciation in other if less impressive ways—and it is in some such spirit that the following story of my four years with the Marine Survey of India is introduced to the reader.

# CHAPTER II

## A TEDIOUS BRIEF EXPLANATION

The Marine Survey of India. The Survey-ship *Investigator*. The Science and Art of Hydrography in general. Deep-sea Sounding. Deep-sea Thermometry. Deep-sea Dredging.

THE present Marine Survey of India, of whose records the following pages are a fragment, dates, as has already been stated, from the year 1874, and was established with a two-fold intention.

Its first and by far its most important object, is a practical and economic one, namely the safeguarding of navigation along the local lines of commerce. Its other object, which came in rather as an afterthought, and is of quite subordinate importance, is a purely scientific one—namely, as opportunity should offer, to gain some knowledge of the hydrography of the local sea-basins, of their depth and temperature, of the deposits forming in their abysses, and of the life that inhabits them.

It is more to my present purpose to speak of the purely scientific discoveries of the Survey, although, as is the quaint custom among English people, these are

as nothing in comparison with obvious and tangible results of immediate practical application.

In its earliest days, the work of the Survey was carried on in boats and small craft; but in the year 1881 there was built in Bombay dockyard, a wooden paddle-steamer of 581 tons displacement, specially designed and equipped for the prosecution of a hydrographic survey according to modern methods.

This little steamer was named *Investigator*. She has a white hull and two buff-coloured funnels, and she flies the blue ensign with the Star of India emblazoned on the field. My history begins with the *Investigator* as I found her in the year 1888, when I joined her in the capacity of Surgeon-Naturalist, and ends when I left her four years afterwards.

There are certain preliminary explanations that have to be made by anyone who wishes to tell an intelligible story of the doings of a modern survey-ship; for we must start with some idea of the ship's economy —of the nature, method, and general bearings of her work. These tedious brief explanations shall here be made as simple as possible, to the avoidance of all precise technical descriptions.

The first question that everyone asks is, What does a survey-ship do? The answer is, Her principal business is to make charts and sailing-directions for mariners. The mariner not only wants to know the shortest and securest routes from port to port, and how

to make a safe approach to land, but he also requires to be informed of any local peculiarities of current and tide; and, moreover, if he be new to a country, he wants to know something of what its harbours and roadsteads promise him in the way of shelter and supplies. All this information it is the business of survey-ships to furnish him with, up to date.

The next question is, How does a survey-ship set about obtaining this information? For answer, let us suppose that we are dealing with an island about which little is known except its geographical position, which we will take for granted. Then the first thing to be done is to examine its topography—to sketch or "plot" its coast-line, and to fix, for beacons, the position of all conspicuous stationary objects ashore. The next thing is systematically to sound out the surrounding sea, in order to determine its bottom-contours, and so to discover any hidden dangers in the way of rocks and shoals. This is done by running line upon line of close soundings, at regular intervals, from near shore to the open depths. Every time a sounding is made the position of the ship is fixed, generally by taking angles between certain stationary natural objects, or certain marks that have been set up ashore; or, when this cannot be done, then in the ordinary way, by chronometer and observation of the sun, or even by dead-reckoning; but the usual

plan is to take angles between marks ashore. These soundings, when they have been reduced to a uniform standard, are plotted down. While all this is in progress, prolonged observations, which often extend over a month at a time, are being made ashore of the local rise and fall of tide. This is necessary, because all the soundings, which obviously must be taken at all states of the tide, have to be reduced to the safe standard of mean low-water mark.

Besides all this, the set and rate of the local surface currents have to be determined. This is done by some sort of "current log," of which the simplest form is a broad, thin plank, shaped something like the cross-section of a boat, and so weighted as to float perpendicularly in the water. When the ship is at anchor the current log, attached to a graduated rope, is allowed to drift for a given time: its direction is noted, and the amount of rope paid out in the given time is observed, and from these data, repeated and corroborated, we get a rough-and-ready knowledge of the surface currents that is quite sufficient for the practical purposes of navigation.

When all the information collected by the topographers and sounding-parties and tide-watchers has been united, verified, standardised and fair-copied, the result is a chart; and from all the other kinds of local information that will naturally be picked up on all sides by observant surveyors in the course of

their steady and long-continued operations, sailing directions of some value will be compiled.

Work of this sort, involving simultaneous exact efforts of several different kinds, demands a large number of hands and heads, and in my time the *Investigator's* company consisted of more than a hundred and twenty, officers and men.

It is also hard work, even when observations of the stars (of which I have made no mention, since they are of only occasional necessity for those who are working in a country that has already been properly measured off by a land-survey) are left out of consideration.

Every morning at daybreak we shall see a little fleet of well-manned boats and launches preparing to leave the ship. One of these will carry a coast-lining party; another will be taking in a load of spars and canvas and whitewash for survey "marks," and men to erect the marks; others are for sounding-parties to explore the shallow waters near shore, in which it would be dangerous for the ship herself to sound.

Occasionally—for this is not an everyday occurrence—we shall see one with a tide-pole and an unhappy tide-watchers' party, off to be marooned on a sandbank or in a mangrove swamp.

Having cast off these, away the ship goes to take soundings on her own account in deep water. She will pick them up again somewhere (if they have

luck) at night; all except the tide-watchers, who will have to wait patiently watching their tide-pole for a month or so.

If we follow these different boats and launches, we shall get some explanatory glimpses of life in the sea-survey.

The coast-lining party will, of course, make for land, and if they are working on the Coromandel coast, they are likely to have a pleasant pull of 3 or 4 miles in nice, choppy, muddy water, before they reach it. If they are surveying among the Laccadives or Andamans, they will probably have to choose their mode of landing between jumping into the surf, or being chucked out in disorder by a playful octave wave. Supposing them and their apparatus safely landed, we shall see them toiling along shore all day with theodolite and sketch-board, sometimes lurching through loose sand, sometimes stumbling through mud, occasionally negotiating a creek, or racing the flowing tide round a headland. At midday they will stop for twenty minutes to refresh themselves: they *may* find a square foot of shade for the purpose, but they will hardly escape the sportive sea-breeze that plentifully peppers their food with sand, and sometimes a large party of those tiny but peculiarly venomous mosquitoes known as sand-flies will come to lunch with them. About sunset they will have to fight their boat through the surf

again, and at nightfall they may pick up the ship at the rendezvous in time for a tub before dinner.

I have often been out with parties coast-lining or putting up marks, and have thoroughly enjoyed the rough-and-tumble in the fresh sea air; but once of sounding in a launch, at which cheerful occupation we may next take a glance, was quite enough for me.

Taking soundings in a launch from sunrise to sunset has, to my thinking, all the tedium of ploughing, without a single one of the quiet alleviations that the philosophic mind is accustomed to associate with the latter rustic art. To and fro, in weary lines quarter of a mile apart, from where the surf begins to think of breaking to the 10-fathom line—in short, just where the impact of the waves reaches a lively climax—the little launch tosses and rolls. Every quarter of a mile, as she runs out and back, her position is fixed (by taking angles between marks ashore) and a sounding is made, so that when her day's work is exhibited on the plane-table, it looks like the picture of a newly-ploughed field, with rows of figures for furrows. Only once did I go out with a boat-sounding party, and the monotony of the sky and sea (which you must view from the low level of a launch to appreciate fully), the monotonous scrunch of the waves and jabber of the little engines, the monotonous chant of the leadsman—all these, together with a certain foolish "exposition" of nausea that at length overcame me, have left on

my mind one of its most indelible impressions of the Marine Survey of India. When the officer in charge of the sounding-party can no longer see to take angles, he wends his weary way to the ship, and he reaches her in the course of time, if there is no particular current against him. But if he gets into a tide-rip—as he very easily may in the Andamans—he has to make the best of things until the ship can find time to look for him.

As for the tide-watchers, we must leave them to the sympathy of those who indulge an introspective turn of mind, for to them there comes, as the gift of fortune, that unspeakable release from worldly distractions that lies beyond all the efforts of all the philosophies. They will retire to a convenient creek in which to set up their tide-pole, then they will run up a rough shelter of canvas, under which to store their three weeks' or month's supply of rations and drinking water, and there, in sole communion with the sky, they will "watch the moving waters." Regularly every half-hour they will be recalled to earth by the necessity of recording the height of the water shown on the tide-pole.

So much for the practical part of the ship's routine, of which I speak merely as an interested spectator, and not with the authority of an actor.

We must next clear our preliminary approaches to

what, for want of a better phrase, I must call the purely scientific work of the ship, in which the naturalist is one of the chief participators. This with us consisted exclusively of deep-sea sounding, deep-sea thermometry, and trawling and dredging.

For *deep-sea sounding* the old, slow, clumsy, and doubtful rope-line has long been discarded, and all survey-ships now use some sort of sounding-machine like that which I shall now attempt, not to describe, but to convey a general idea of.

The sounding apparatus used by the *Investigator* in my time, consisted of a Sir William Thomson sounding-machine and a Baillie sounding-rod. With this we used, instead of a rope, a fine line of steel wire like a piano string. The advantages of this over rope are—that it offers no surface for friction, and can therefore be paid out and hauled in quickly; that it is not buoyant, and therefore is not liable to drift away among under-currents; that it does not increase in weight by getting water-logged; and lastly, but most potently, that it is compact and manageable, since 4000 or 5000 fathoms of it can be reeled on a light drum only 2 feet in diameter.

When in use, the drum on which the sounding-wire is reeled revolves on a common axle with the driving-wheel of a steam-engine of almost toy proportions, and by this means the wire, after having been eased out to make a sounding, is reeled in again when

the sounding is taken. As the drum revolves it works an arrangement of cog-wheels, by which the exact amount of wire paid out is registered in units, tens, and hundreds of fathoms, on a series of dial plates. When not in use, the whole machine with its reel of sounding-wire occupies about as much space as an ordinary travelling trunk, exclusive of the pipes which, when it is in action, convey the motive steam-power from the engine-room.

The sounding-rod is a metal cylinder, about 2½ feet long, and about as stout as an old gentleman's Malacca walking-cane. Its lower part is hollow, for sticking in and bringing away a sample of the ocean bottom, after the manner of a cheese-taster's gouge; its upper part is solid and ends in a ring, through which the sounding-line is rove.

The sounding-rod must be light, otherwise a wire-line would never be strong enough to haul it in from a great depth; but it is equally essential that it should be heavy, otherwise it would never reach the bottom.

These two conflicting requirements are reconciled by weighting the sounding-tube with heavy sinkers, which carry it to the bottom quickly, and then automatically disengage themselves and leave it free to be hauled up alone. Simple as it is, I shall not attempt to describe the mechanism by which the sinkers detach themselves when the sounding-tube strikes the bottom. However, the ordinary reader will understand the

principle that underlies it if he can imagine the sinkers to be threaded on to the sounding-tube in a row, exactly like a row of beads on a needle. If the needle be held perpendicularly, point downwards, the beads will, of course, slip off. But if, when the needle is in this position, the lowermost bead be kept from falling by a loop of wire passing down beneath it, then so long as this loop is kept taut from above, the beads cannot slip off, since the lowermost bead is kept in place by the pull on the loop. But the moment the tension on the loop is relaxed, the lowermost bead will fall off and the others will slip off after it. "Well, then, that's the humour of it," as Corporal Nym says; but if any reader wishes to have an exact acquaintance with the apparatus, I would refer him to pages 60 and 61 of the first volume of the *Narrative of the Voyage of H.M.S. Challenger.*

It must be mentioned with regard to the hollow part of the sounding-tube—the part that sinks into and brings away a sample of the ocean-bottom—that its mouth is valved, so as to let the mud in but to prevent its falling out again. As for the sinkers that carry the tube down, they slide off on the bottom and are no more seen.

For *deep-sea temperature observations*, maximum-minimum thermometers, specially protected against the enormous hydrostatic pressure to which they are ex-

posed in the ocean depths, are used. We shall presently come to this subject of hydrostatic pressure; for the moment, it is enough to say that at the greatest depths it is sufficient to pulverise an ordinary thermometer, and that even at moderate depths it will so influence the instrument as to give us a reading mainly determined, not by temperature, but by pressure.

Deep-sea thermometers are protected against this pressure by having the bulb, and often the column also, enclosed in another bulb or tube which is partly filled with spirit. The pressure is then exerted, not on the thermometer itself, but on the outer tube and on the elastic spirit-vapour that fills the outer tube. While, for further protection against gross mechanical injuries, the whole instrument is encased in a copper cage.

When in use, the instruments are lashed on to a sounding-line; and in the *Investigator* no deep-sea sounding was considered complete unless it was accompanied by, at least, a reading of the temperature at the bottom.

Everyone knows so much about *trawling and dredging*, that it would be superfluous to speak of these operations in any detail here. In the *Investigator*, in my time, we almost always used, when working in deep water, an American reversible trawl,

about which the great advantage is that it does not much matter whether it turns over in its descent to the bottom or not.

Our deep-sea trawl, which was used as a dredge, consisted of a stout iron beam, about 14 feet long, with a large stirrup-shaped iron hoop standing back at right angles at each end. The dredge-rope was attached to the middle of the beam, and the dredge-net to the shoes of the stirrups.

The net is a wide-mouthed, V-shaped bag, between 25 and 30 feet long. Just inside its mouth is a second net or curtain, which does not interfere with the passage of animals inwards, but makes it hard for them to find their way out again. Its tail is heavily weighted with an iron shot, which keeps the net stretched in its descent, and also keeps it down as it trails along the bottom. All round the net, from the angles of the mouth to the tip of the tail, there runs a secure rope, and to this are fixed swabs, in which many animals become entangled.

Our trawl was worked with a strong wire rope, which was eased out and reeled in by a special machine, something like the sounding-machine much magnified. Sinkers had to be used to carry the trawl to the bottom quickly; and to guard against sudden strains, which might snap the rope, a special elastic apparatus, known as an "accumulator," was attached to the block over which the rope played as

it passed clear of the ship. Our accumulator was of the American pattern, and consisted of a row of thick indiarubber disks held between iron guides. These by their compression not only gave timely notice of any sudden strain on the rope, but always tended to keep the tension even.

As we shall often be referring to the wonderful "jabberwocky" animals that the deep-sea trawl brings up, our preliminary observations will have to be still further prolonged, in order that we may form a rough idea of that strange other world beneath the waves in which these animals pass their weird existence.

# CHAPTER III

## THE WORLD BENEATH THE WAVES

The Bed of the Ocean. River-borne Deposits. Oozes of Animal and Vegetable Origin. The Red Clay of the Still Abysses. The Pressure of the Ocean. The Cold and Darkness of the Depths. The Lampbearers of the Everlasting Night.

Of the world beneath the sea, and of its inhabitants, our ancestors—even our immediate predecessors—had little information and scant idea, and it was not until the middle of the nineteenth century, when submarine cables came to be talked about, that our knowledge of the physical geography and natural history of the bed of the ocean began to approach the exact stage.

Those who wish to know something of the steps by which this knowledge has advanced to its present state should refer to the *Summary of the Scientific Results*, as well as to the early chapters of the *Narrative of the Voyage of H.M.S. Challenger:* the following sketch is meant merely for those who have not yet given any special attention to this interesting subject.

If we could for a moment run all the water out of one of the great ocean-basins, and lay its bed bare, we should find ourselves in a land a good deal different from any to which we are accustomed. Many of the main features we should, of course, recognise: we should find hills and table-lands, and plains and valleys, and we should see mountain-slopes rising, with little-varying degrees of steepness, towards the continents and islands that form the dry land. But what would astonish us about them would be their vastness, their simplicity, and their uniformity—in other words, their want of character, due to the fact that the natural agencies, which should add beauty of feature, are non-existent.

The dry land is the scene of an unceasing tumult of plastic forces: sun and frost, rain and flood, glacier and torrent, wind and wave, are continually at work changing its appearance almost after the manner of a living spirit. But beneath the ocean none of these sculpturing forces are known. There there is little or no change of temperature, and no violent movement of water, consequently the landscape has no detail, and its style is vast, monotonous, and unvaried.

For instance, if we could walk straight across the Bay of Bengal (which, though we call it a bay, is really a great inlet of the ocean) from Madras to the Andamans, we should for the first 10 or 11 miles

traverse a decline so imperceptible as to seem almost level: we should then for another 30 miles descend a sudden and very steep slope, until, at about 40 miles from shore, we should reach level ground at a depth of about 11,000 feet below the sea-line. Once there, we should walk for more than 600 miles over a plain as flat as a tea-tray, until we came to a corresponding ascent up to the Andaman shore.

In our journey across our supposed dried-up ocean bed, though we should have no scenery to admire, there would be much to interest us in the ground beneath our feet. We should, of course, find numerous remains—shells and skeletons—of all sorts of sea-animals; but, for reasons to be presently given, we should, when we had made our first descent of about 600 feet, see nothing in the shape of seaweed: however, it is to the ground itself that we must turn our attention.

After we had left behind us the rocks and reefs and shingle and sand of the shore, we should come to mud: it would most likely be of a dark bluish colour, and it probably would not smell very sweet. This mud is the sediment that has been brought down by the rivers, and is therefore derived from the land.

In certain places where no rivers of any size flow into the sea, as for instance, in the neighbourhood of coral islands, we should probably find a

greyish or whitish mud, made up chiefly of coral detritus. But in the neighbourhood of most of the continents we should find—as all round the boundaries of the Bay of Bengal—a fringe or steep "shoot" of dark-coloured mud, and the breadth of this fringe would vary, according to the number and volume of the rivers in the vicinity, from 60 to 300 miles.

To resume our imaginary journey from Madras to the Andamans. At a distance of about 150 miles from shore the mud would begin to change: it would gradually become more and more gritty, and lighter and lighter in colour, until we should at last find ourselves walking on ground something like dirty chalk. This is the Globigerina-ooze that forms such a large part of the bed of the ocean in tropical and temperate regions.

Globigerina-ooze—so called from the species most constantly and most abundantly found in it—is, for the most part, made up of myriads of dead shells of the minute and lowly animalcules known as *Foraminifera.* They belong to the very lowest class of the animal kingdom, and they swarm throughout the warmer seas; and as they die, their shells, which usually but not always are made of carbonate of lime, fall to the bottom—like, as has been aptly said, a perpetual shower of rain—and there accumulate, to form vast beds of sediment not very different from the

familiar chalk of south-eastern England.* The shower of shells may be, and often is, also falling where the blue mud is being deposited, but there it is quite lost in the infinitely more voluminous mass of river-borne sediment; so that it is only at a considerable distance from land, and when all the river-borne material has settled, that we get pure Globigerina-ooze.

But Foraminifera are not the only animals whose remains form, or help to form, oceanic deposits. The surface waters of the open sea swarm with delicate shell-secreting animals of other and far higher kinds. Conspicuous among these, in certain latitudes, are the sea-butterflies or *Pteropoda*—small mollusks not distantly related to the cuttle-fishes—whose shells resemble little caps and purses of the finest glass. When they die, their shells too fall to the bottom, and sometimes in numbers sufficient to overwhelm the Foraminifera shells, and to turn the Globigerina-ooze into Pteropod-ooze.

In our imaginary journey across the Bay of Bengal, we should meet with nothing but the deposits mentioned above. For the first 150 miles from Madras there would be blue and brown muds. These would

* Not all the Foraminifera whose shells are found in deep-sea ooze live at the surface, though most of them do; some undoubtedly live at the bottom. Again, not all Foraminifera are minute: some of the species that inhabit shallow water in the tropics are as big as a sixpence or a shilling, and there are certain species among those, whose shells are formed of sand, that attain the size of a crown-piece.

SHELLS FROM GLOBIGERINA OOZE.

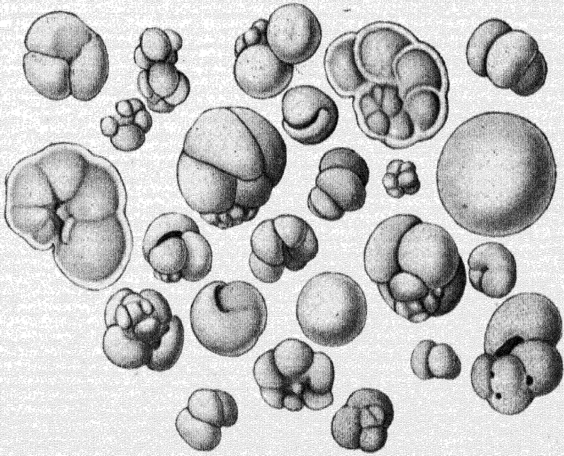

FIG. 1.—Shells from Foraminiferal ooze, brought up in the sounding-tube from a depth of about 1100 fathoms, in the vicinity of the Laccadives; enlarged about forty times. In the natural state the shells cohere together; but those here shown —which consist chiefly of *Globigerina*, with a few *Pulvinulina* and *Orbulina*—have been separated by repeated washing and careful drying.

[*To face page* 32.

gradually become grey as the showers of shells began to prevail over the gradually-diminishing showers of river-borne silt, until, before we were 300 miles away from land, we should be on pure Globigerina-ooze, mixed only with the remains of other sea-animals, and perhaps with pieces of water-logged pumice-drift. We should continue on Globigerina-ooze until we came within 100 miles of the west coast of the Andaman Islands, where we should almost certainly see some patches of Pteropod-ooze; and, further on, we should find ourselves on a tenacious whitish clay, not unlike Globigerina-ooze in colour and chemical composition, but differing from it in consisting almost entirely of the finely-comminuted *débris* of the coral-reefs that fringe the islands.

We must, therefore, go outside the comparatively narrow limits of the Bay of Bengal, whose greatest depths do not much exceed 2000 fathoms, if we would make our idea of the ocean floor more complete.

And first, we must take note of the fact that the surface waters of the ocean support multitudes of microscopic animalcules, nearly related to the Foraminifera, but differing from the latter in having shells of silica, or what we may without any serious misrepresentation call flint. These hard-shelled animalcules are called *Radiolaria*, and although they are not nearly so abundant as the comparatively soft-shelled

Foraminifera, yet some of their shells are almost always present in Globigerina and other ooze, and in certain corners of the ocean they are sufficiently numerous to form an almost pure siliceous deposit known as Radiolarian ooze. For reasons that will presently appear Radiolarian ooze is met with only at great depths.

But the animalcules, and especially the Foraminifera, whose mortal remains collect to form these calcareous and siliceous oozes, are only found in profusion in oceanic waters of a certain necessary warmth. In the colder waters of the higher latitudes they are not numerous enough to give a dominating character to the sediment that subsides to the bottom of the open ocean.

Now, amid the teeming life of the ocean there are to be found in abundance certain microscopic plants of the lowliest kind. We must call them plants, because they belong to the vegetable kingdom, but they are not in the least like any plants that are visible to the naked eye. Not only do they swarm throughout the sea, but they are also universally diffused in fresh waters, and, in short, wherever there is moisture. These humble microscopic "plants" are known as Diatoms, and in the scheme of Nature they stand and wait at the bottom of the class to which the seaweeds and moulds belong, being, in fact, rather nearly related to the Bacteria which have

nowadays become so popularly unpopular. Many of them are enclosed in an excessively fine shell of the nearly-indestructible substance silica, like the Radiolaria.

When the oceanic Diatoms die, their shells, of course, sink like an invisible dust to the bottom; and although in warm latitudes these are lost amid the downpour of Foraminifera, yet in colder regions, where surface Foraminifera are few, the Diatoms hold their own, and at length may collect as a pale siliceous deposit known as Diatom-ooze.

But neither Diatom nor Radiolarian ooze, nor yet —abundant as it is — Globigerina-ooze, cover all, or nearly all, of the floor of the open ocean. Far more extensive than all these oozes combined is a deposit called by its discoverers in the *Challenger*, red clay, which, when examined under the microscope, is found to consist in large part of altered volcanic materials. This red clay is found pure only at the very greatest depths. Mixed up with it, of course, are certain indestructible remains of marine animals—spicules of siliceous sponges, sharks' teeth, ear-bones of whales, etc. — such as are also to be found in all marine deposits; but a great part of it is derived from the minute particles of the volcanic and cosmic dust that floats invisible in the atmosphere. Though this dust is co-extensive with the atmosphere itself: though probably it exists everywhere, and is falling unseen

everywhere; yet everywhere except in the solitudes of the ocean it is lost amid other grosser matter, and it is only in the remote abysses of the ocean that it falls unmixed with other material, and in the fulness of time aids in forming a deposit of appreciable thickness.*

The question will at once occur, How can such a pure deposit of volcanic (and cosmic) origin ever be formed? We can understand that the sediment brought down by the rivers must gradually subside

* The main aim of this sketch is to give a clear idea of the manner of formation of the chief deposits that are accumulating on the bed of the ocean, and not to describe in any detail the composition of the deposits themselves. It must, however, be mentioned that, according to its discoverers, a large part of the red clay results from the disintegration of floating pumice (*i.e.* volcanic material carried by water, not by air). It must also be mentioned that the red clay is peculiarly rich in such resistent animal remains as sharks' teeth and ear-bones of whales, and this, not because animal remains sink in any particular abundance in the remote regions where red clay is in process of formation, but because, owing to the paucity of the material that goes to form red clay, the animal-remains that do fall there are much more slowly entombed than they are elsewhere. Another important fact that must be mentioned is, that metallic concretions—*e.g.* manganese nodules—are particularly abundant in the deposits from great depths, these being the result of the slow chemical decompositions and recompositions that take place under the peculiar abyssal conditions. Finally, it need hardly be explained that the various oceanic deposits are seldom perfectly pure, and that they are not separated from one another by hard and fast boundary lines, but that, like most other things in Nature, they grade into one another. Even in red clay, such parts of the other organic oozes as are not soluble will be found.

before it is carried very far from land; but are not the shells of *Foraminifera*, and Pteropods, and *Radiolaria*, and Diatoms, always being showered down? The answer is, that these shells are, indeed, falling everywhere, and that although in water that is not too deep they reach the bottom safely and cover each other up, yet in the abysses of the ocean they are either dissolved or otherwise destroyed before they get to the bottom. The Pteropod and Foraminifera shells, which consist of carbonate of lime, are dissolved by the sea-water, and may disappear completely, but even the resistent Radiolarian and Diatom shells, though they are not completely dissolved, yet at last get broken and chemically altered, until finally, there is little left to fall in the great depths of the ocean but the settling volcanic dust.

This sketch, for the materials of which I am indebted to the published researches of Sir John Murray and the *Challenger*, must serve for an idea of the bed of the ocean, and we may now go on to consider, in a general way, the peculiar conditions of life in the ocean depths.

Many people know the sensation of diving to the bottom of a swimming-bath; it is felt in the drum of the ear, where the increased pressure of only a few feet of water gives rise to a painful feeling of tension. At the surface of the water, as everyone knows, the

pressure of the atmosphere amounts to 14.7 pounds per square inch. At a depth of a little over 33 feet below the surface the pressure is twice this amount, a column of water of this height having the same weight as a column of the atmosphere. At a depth of about 67 feet the pressure is that of three atmospheres, or about 44 pounds on the square inch. At 100 feet the pressure will have increased to something near 60 pounds, and so on, until at a depth of 2000 fathoms it will, allowing for the increasing density of the water at increasing depths, be more than 2½ tons on every square inch.

Marine animals of many kinds live under this enormous pressure. They do not feel it any more than we feel the weight of the atmosphere, but if they happen to be dragged up to the surface by a dredge, their condition then, as Dr Günther has put it, becomes, only in an extraordinarily intensified degree, that of a man who has been carried too high in a balloon; the fluids of their body, becoming released from their accustomed pressure, expand and burst the flesh, and life is generally extinct before the surface is reached. These disastrous effects are most manifest in creatures like fishes, that have no firm shell to hold them together. When a true deep-sea fish is brought to the surface, its belly is blown up until its intestines often protrude, and its eyes start out of their sockets, these being sure signs

that life for it is impossible at the ordinary barometric pressure.

Everyone knows what happens when on a sunny day the sky suddenly becomes overcast with rain-clouds: the sunlight is changed to gloom. We can, therefore, imagine what things would be like if, instead of a layer of cloud, a layer of water 100 fathoms thick were to interpose between us and the sun: the gloom would deepen into darkness. At 200 fathoms, even if the water is quite clear, there is not enough light to affect a photographic plate, and this is the condition of affairs in the depths of the ocean. There can therefore be no plant life, because plants can only grow in sunlight. We should also expect to find—if we believe in natural selection, and look upon eyes as organs that can only be kept up to the mark where there is useful work for them to do—that the eyes of the animals would be in some way impaired, and this we do indeed find to be the case with many animals that live actually at the bottom in great depths. There are, for instance, certain animals related to the crabs and lobsters (crustacea), certain mollusks and a few fishes which undoubtedly pass the whole of their life *at, or close to, the bottom* of water that is over 500 fathoms deep, and among these it is rare to find any that have eyes in any way comparable with those of their shallow-water relatives. Among

such fishes and mollusks there are several species that have the eyes reduced to hidden and useless rudiments, and numerous species that have eyes of a most degenerate kind; and among such crustaceans there is quite a large number of species in which, though the eye-stalks that their shallow-water relatives possess may be present, the eyes show all degrees of degeneracy, from grave imperfection to complete absence.

But, unfortunately for a clear and concise account of this matter, it is impossible to decide, with the majority of animals brought to light by the deep-sea dredge, whether they did or did not come from the very bottom. Most fishes, many mollusks (especially those related to the squid and octopus), and a large number of crustacea (those, namely, after the prawn and lobster kind), are active swimmers, who, though they may at times descend to the "dark, unfathom'd caves of Ocean," may at other times ascend to regions where there is *some* little daylight. These we shall not expect to have degenerate eyes; on the contrary, knowing what we do of certain land animals (such as owls and night-jars, and certain fruit-bats, rats, cats, and lizards) that come out only at night or in twilight, we may rather expect them to have particularly keen vision and large eyes for the better appreciation of such poor light as does exist. And of this expectation we find, in fact, much justification. Among those crustacea, mollusks, and fishes, which, though we dredge them

only in deep water, we have no reason to suppose are rigidly restricted to depths that are quite beyond the reach of solar illumination, we do find a considerable number of species that have far larger eyes than their shallow-water relatives—some of the fishes having these organs of startling size.

Again, further to complicate the matter, although the depths below 200 fathoms may be impervious to sunlight, we do not know to what extent these sunless depths may be lit up by the animals themselves that live in them. Everyone is familiar with the nocturnal "phosphorescence" of the sea. Now this "phosphorescence" would almost seem to be one of the properties of marine animals, so constantly and universally is it exhibited. But beyond this general source of light, there are many species of deep-sea fishes which possess special luminous organs comparable in efficiency with those of fire-flies and glow-worms, so that it is quite possible that the depths may in places have a weird and imperfect illumination of their own. And this will give us another explanation of the curious, and at first sight paradoxical, fact that many species of these animals that live away from sunlight possess eyes of wonderful size.

If the light of the sun is cut off by a thick screen of water, so also, as we know from our sensations on a cloudy day, is his heat. For instance, in the open

part of the Bay of Bengal, where the mean surface temperature is about 80° Fahrenheit, the temperature at a depth of 100 fathoms is only about 60°, at a depth of 300 fathoms not quite 50°; while at a depth of 2000 fathoms the temperature all the year round is only 3° above freezing point. Though this low temperature is an effect, it would be incorrect to call it the *direct* effect, of the obscuration of the sun: as a matter of fact, the bottom temperature of the Bay of Bengal is believed to be directly determined by under-currents, that is to say bottom-currents, of cold water constantly creeping onwards from the South Pole. But, as the shepherd's philosophy informed Touchstone, "a great cause of the night is lack of the sun"; so the cold of the bottom of the ocean may be rightly attributed in the last resort to the same great cause.

We see, then, to conclude the matter, that life in the rather monotonous depths of the ocean is conditioned in ways a good deal different from the life of the land and of the littoral.

In the first place, plant life is impossible, because there is no sunlight, although bacteria and other microscopic parasitical plants that do not require sunlight may and do exist there. But the bulk of life is animal life accustomed to an enormous hydrostatic pressure, to a low temperature, and to gloom or dark-

ness, or at most to an intermittent "phosphorescent" shine of no great brilliance.

On first consideration, it would seem as if the absence of plants must be an interdiction of more than pontifical potency on animal life; and such indeed would be the case, if there were not an abundant outside supply of food derived in the last resort from the vegetable kingdom. This outside supply may come either from the rivers, which must wash an enormous amount of organic matter into the depths; or from the surface of the ocean, where of course the creative interaction between the animal and vegetable kingdoms is in vigorous progress, and must at last lead to a perpetual shower of dead stuff, suitable for food, into the abysses beneath. It must, further, be remembered that there is no abrupt division between deep and shallow, but that the depths are reached by a series of slight overlapping gradations, and that for this reason there must be a continuous gradual circulation of organic matter between the shallow zones of plant life and the deep regions of no-plant life. But even when these three factors have been duly considered, we shall expect to find that the depths near the continents are more prolific than the far-off abysses of the open ocean; and this appears to be actually a fact. For although animals have been brought up from the greatest depths to which the dredge has been lowered, yet if one expects to get a

really large haul of deep-sea animals one should work —at anyrate in Indian seas—in water between 200 and 1000 fathoms deep, not too far from shore.

Finally, although the physical conditions of life in the depths of the sea are so peculiar, the workings of life there do not seem to be shut in much narrower compass than they are elsewhere. There, as elsewhere, the three great exigencies—to find something to eat, to avoid being oneself eaten, and to disseminate one's species—give rise to a perpetual struggle for place, in which the fittest are successful; and this in turn must lead, in every class of the animal kingdom which is there represented, to a series of transformation scenes, in which everything is, like Fluellen's picture of fortune, "turning, and inconstant, and mutability, and variation."

# CHAPTER IV

## A NOVICE IN THE ANDAMANS

Introduction to the Andamans and to the *Investigator*. The Coral-reefs of Port Blair Harbour. Initiation into the Complete Art of Deep-sea Dredging. The Wonders of the Tow-net. A Political Venture to the Little Andaman Island. The Coco Islands.

I SHALL never forget the day, in November 1888, when I took ship at Calcutta to join the R.I.M.S. *Investigator*, which was then engaged in survey work among the Andaman Islands.

I had for more than two years been stationed in certain particularly arid parts of the Punjab frontier, where life of any sort, whether animal or vegetable, comes very far short of one's anticipations of the Oriental region, so that the prospect of seeing one of the biological paradises of the East raised in my mind a glow of hope that still fires me as I think of it.

Nor were my expectations weakened when on the fourth day the islands broke in sight, their green, forest-clad heights rising out of a clear sapphire sea, a snow-white dividing line of reef-surf and coral-beach, full of promise, coming into view as we drew closer.

The *Investigator* was away among the islands when we reached Port Blair, and it was not until her return on the 24th November that I made the acquaintance of her officers, and took stock of the little department assigned to my charge on board.

The officer in command of the survey at that time was Captain Alfred Carpenter, R.N., D.S.O., whose special knowledge of deep-sea hydrography had been drawn from the fountain-head of the *Challenger* during her now historic voyage.

The "first" was Lieutenant E.C.H. Helby, R.N., whose term of service with the Indian Marine Survey was then, unfortunately, drawing to an end.

Among other shipmates to whom I was then introduced were Lieutenants E. J. Beaumont, G. L. Mathias, and W. B. Huddleston, all of whom, though at first, like true British sailors, inclined to regard as a curiosity a man who had deliberately given up a shore-going billet to come to sea, soon became fast friends and supporters of the surgeon-naturalist's department.

Nor must I forget to mention Engineers C. Fuller and F. S. Lamb, the latter of whom, like that emblem of his craft the great steam-hammer which can moderate its strength so as to crack a nut without hurting the kernel, could mend you a microscope with as much ease and dexterity as he could control his engines; and Mr Peterson, the gunner, who presided over the dredging-gear.

The other officers of the Survey had been left in some out-of-the-way island as a boat-party, so that I did not come to terms with them on this occasion.

I found the surgeon-naturalist's quarters on the *Investigator* to be, as things on board ship go, palatial.

The surgeon's equipment and all the gallipots were lodged in a little cabin between decks, which was not meant for work; but the natural history work-room, which was on deck a little forward of mid-ships, was quite 10 feet long and 8 feet broad, with windows all along one side, and in this spacious room I soon learned how to stow all my worldly belongings and still find infinite space for books, specimens, microscopes, aquaria, and all the machinery and material of my work. I could even on occasion, without disturbing my gear or knocking-off work, find room for any officer who did not wish to emphasise the fact that he was off duty.

Soon after I had settled myself in these capacious and convenient quarters, Captain Carpenter himself took me to see the coral-reefs in the north bay of Port Blair harbour: it was my first introduction to a growing coral-reef, and I only wish that I could describe a small part of what I saw.

I suppose everyone nowadays knows that coral is the calcareous external skeleton of lowly organised

animals, or "polyps," having a strong family resemblance to the familiar sea-anemone, and that a coral-reef is a mass of rock gradually built up in the main by the continuous budding and branching and dying down of many different species of coral-polyps.

If the reader will imagine a scrub jungle on a very gently sloping incline, in which the spaces between the various kinds of bushes gradually become filled up, partly by the increase in size of the bushes themselves, and partly by all sorts of litter from the branches and their inhabitants, until at last the jungle is a solid mass of dead wood with only the outermost twigs still living and growing in the fresh open air, he will have some sort of idea of the way in which a coral-reef is formed.

It must not be supposed that all the different kinds of coral-polyps burgeon and branch like shrubs, or that all take part in forming coral-reefs. Some species live a solitary life, or at most grow out into small plots or encrusting patches, and such "solitary" corals have been found in all seas and at all depths up to nearly 3000 fathoms. The reef-making corals, however, are found at the present day only in tropical and subtropical seas, and there they can exist only in the warm, shallow water, from high-water mark down to about 30, or exceptionally 50, fathoms.

Coral-reefs occur in three principal forms: as fringing reefs close to shore, and in part laid bare at ordinary

low tide; as barrier reefs far out at sea, such as the Great Barrier Reef, which, at a distance of from 15 to 100 miles from land, skirts almost the whole north-eastern coast of the Australian continent; and lastly, as atolls or island-rings in the open ocean.

In the parts of Indian seas that are surveyed by the *Investigator* only fringing reefs and atolls are met with; the former in those parts of the Andaman Sea and Bay of Bengal where the water is not too turbid with river-borne sediment, the latter in the Laccadive and Maldive Archipelago; but the series of coral banks which flank the western shore of the Andamans may perhaps represent a discontinuous barrier reef.

The most perfect depths at which to observe a living coral-reef in these seas are from 3 to 10 fathoms, according to the amount of daylight at the time. One cannot make out much detail, even when the sea is quite calm, by merely looking down over the boat's side unless one has a water-glass. This is a wooden funnel, with a window of good plate-glass in the broad end and a pair of handles about halfway up. Taking a good grasp of the handles, you run the funnel overboard, push the window end well below water, and put your eyes to the narrow end, and then a perfect picture of the bottom is before you, free from all the distortions caused by ripples and surface reflection, and free from glare.

And what a picture it is to a man who comes from

museums and books. Looking back after thirteen years, I can only remember visions of fairy groves and glades, lit by a strange ethereal light, half moon half sun, where, among Christmas-trees of purple and blue and golden green, fishes painted like butterflies flitted and hovered.

After some preliminary dreams we used the water-glass for the practical purpose of spotting desirable specimens, which lascars, armed with crowbars, dived for and sometimes secured, until our boat was full. Then we went back to the ship, where I fancied the officer on duty received us with a certain amount of constraint, for he knew—what I had still to learn—that the result of that day's work would provide the ship with good store of intolerable smells for a fortnight, decaying coral flesh being only one degree less ancient and fish-like in odour than very old whale-blubber.

In that day's collection were many genera and species of corals which even yet I have never found time to identify with certainty.

What chiefly concerned me at the moment was to search out and preserve from my quarry all the numberless small sea-animals that live in the crevices of growing coral, much as small land-animals live among the leaves and branches of trees and shrubs. Even as a beginner, I was able to pick out several species of fishes, several kinds of mollusks and molluscoids, a multitude of small crabs and other crustaceans,

some sea-worms and sea-urchins, and numerous other still more lowly organised creatures; and even a beginner could not fail to notice that, both in colour-markings and in form and sculpture, these little lodgers often had a singular resemblance to the host under whose protection they lived.

On the third day after I joined the ship, Captain Carpenter undertook to initiate me into the mysteries of deep-sea dredging. When we had steamed out a few miles to the east of Port Blair, the ship was stopped and brought head to wind, and a sounding was taken with the deep-sea lead, which showed 244 fathoms and a bottom of slimy, black mud. The temperature at the bottom was not taken on this occasion, but the ship's bearings by the land were noted, so that her position could be afterwards worked out.

The dredge was then lowered away from the fore-yard, the dredging-rope having been led first through a hawsehole in the bows of the ship, and then through a steel block pendant from the bow-sprit, arranged so that the strain should be borne by the accumulator. As the rope was slowly payed out the ship was kept slowly moving astern by an occasional turn of the paddles, and the same slow movement was continued after the dredge had reached bottom, a very careful watch being all the while kept upon the accumulator.

After dragging for some time under the eye of

the commander, the dredge was slowly hauled in, the rope being reeled over a surging-drum attached to the ship's steam-winch. A second sounding was then taken, which showed 112 fathoms, and the ship's bearings by the shore were again noted. The dredge was at last hove up to the foreyard whence it had started, and was then fished inboard on to the forecastle deck and handed over to the expectant surgeon-naturalist.

Unfortunately on this occasion the net contained more of mud than of anything else, and the washing of this mud through a series of strainers kept me fully employed until after nightfall.

The objects of chief interest in this haul were some specimens of the curious, fragile, pancake-like starfish *Palmipes*. I was afterwards much impressed to find that of the three other species of this genus, one is an inhabitant of the English Channel and Mediterranean basin, another is found in the Bay of Bengal and off Japan, while the third is only known from the sea north of New Guinea.

The next piece of collecting-gear with whose working I had to become familiar was the tow-net or surface-net. This, which is like a jelly-bag with a valve-like curtain inside its mouth, and a lamp-chimney tied in its very long tail, is simply allowed to drift from the ship at the end of a long line. When brought on board, the lamp-chimney, into which the

larger objects captured have settled, is removed for future examination, and the net is turned inside out and carefully washed in a bowl of sea-water for the multitude of minute animals that have become entangled in its threads.

I never put out the tow-net when we were dredging, because it was usually more than I could do to attend to the trawl and swabs before their contents began to decay; but it was our invariable rule to send it overboard whenever the ship was at anchor, or when she slowed down to take a deep sounding merely.

I shall never forget my first few days with the washings from the tow-net, when for the first time in my life I saw the living *Globigerina*, whose shells form the ooze, and *Thalassicolla*, and Ascidian tadpoles, and the larvæ of *Amphioxus* and *Lingula*, and the living mechanism of a host of other transparent oceanic animals which up to that time I had known only from books and pictures.

At the end of my first week on board, the ship left Port Blair to carry a small political mission to the Little Andaman, an island that lies about 25 miles southerly of the main Andaman chain, and whose savage little inhabitants were at that time (1888) not quite under control, and, indeed, had very little respect for anybody.

On reaching the island, it was not deemed prudent

to land in force—the mission being a peaceful one—until the inhabitants themselves had been consulted. This was done by depositing a peace-offering of hoop-iron and bunches of plantains upon the shore, and then retiring to the boats. When our party saw from the boats that these had been accepted, they landed boldly, and were received with friendliness by all except one old woman. The following morning a party from the island, moved by certain cravings for a higher life, paid a visit to the ship, and finally left on board a small embassy of intrepid spirits to be carried to Port Blair to interview the Chief Commissioner of the Islands.

I spent my time, while these negotiations were going on, dredging from a cutter with a small hand-dredge, and, among other things, I got some crustaceans that were afterwards found to be extremely rare.

We went back to Port Blair to land the local politicians, and then left for the east coast of India, where the main survey-work of the season lay, touching *en route* at the Coco Islands. These are a group of three uninhabited islets lying in the rocky sea between the Andamans and Cape Negrais in Burma. Although, geographically, they appear to belong to the Andamans, yet the fact that they are covered with coconut palms, which are not found—except where they have been planted by European officers—on any

of the Andaman Islands, gives them a very remarkable interest of their own.

The names of the islets are—Table Island, which is a mere plot of not much more than 1000 acres; Great Coco, which is quite a respectable island, more than 7 miles long; and Little Coco, which is about a fifth the size of Great Coco. On a clearing on the highest point of Table Island, at an elevation of 105 feet above high-water mark, stands an iron lighthouse, 90 feet high, whose powerful fixed light is visible at a distance of 22 miles. In the days before the lighthouse, the Cocos were a terror to mariners, on account of the reefs by which they are surrounded and the cruel currents which sweep round them, to whose power the remains of several wrecks still bear witness.

On this occasion we merely touched at Table Island to verify the position of the lighthouse, as several reports had been made that its latitude was not correctly shown on the charts. The observations taken by the officers of the *Investigator*, however, proved that the charts were perfectly correct in this respect.

It being the season of the north-east monsoon, we landed, but not altogether without difficulty, on the southern beach, and on our way to the lighthouse we passed the inevitable little grave-mounds of our wandering race. Go where you will, from the remotest coffee-plantations of southern India to the camping-

grounds beyond Cashmere, from the wind-swept deserts of Baluchistan to the tepid jungles of Burma, you will always find, rudely fenced in, some humble little green monument upon which imagination may, with likelihood to lead it, trace the proud inscription, "*Quæ caret ora cruore nostro?*"

The little graveyard here was the resting-place of the family of a former lighthouse-keeper. The wife had brought them to share her husband's exile, and they had all been drowned in attempting to land in bad weather.

As, during my service on the *Investigator*, we visited the Andamans and Cocos several times again, I shall defer speaking of the natural history of the islands until another occasion.

It is not worth while for me to record my hasty impressions of the pigmy Negrito inhabitants of the Andamans, who have been carefully studied from the sociological point of view by residents like Man and Portman, and from the anthropological point of view by numerous European workers of established reputation.

Nor, at this distance of time, can I say anything about the Andamans as a penal settlement, more than that in the general condition of the better-behaved convicts I seemed to see in progress the conversion of an incoherent mass of dissipated humanity into a coherent smooth-working social machine, without any painfully-evident compulsive force.

On our way from Table Island to False Point, where our survey of the east coast of India was to begin, we ran a line of soundings across the Bay of Bengal, and found the bottom to consist principally of blue mud washed down by the great rivers of India, with a few shells of Foraminifera interspersed.

# CHAPTER V

## ON THE ORISSA COAST

At False Point. A Melancholy Shore. A Holy Land: the Temples of Jaganath and Kanárak. The Chilka Lake. A Deserted Village. Surf Boats and Boatmen. Strange Jelly-fishes and Zoophytes. Messmates of the Sea. The Concert of the Sea: Musical Crabs and Fishes. Courtship among Fishes. Mothers and Mother's-milk among Fishes. Lancelets. Scientific and Economic Possibilities of the Orissa Coast.

ON the 12th of December 1888, the *Investigator* reached False Point in Orissa, and from that day until the 21st of March following, the officers were busily occupied in all the ways that I have already in a former chapter described, charting the coast and its anchorages from that wretched port southwards, along the Mahanaddi Delta, to Gopalpur in the district of Ganjam.

Though this part of India is not to be commended for its scenery, which consists chiefly of slimy creeks and screw-pine swamps alternating with long stretches of drifting sand washed by a muddy sea, yet to the Hindu world it is one of the most interesting spots in existence, because it contains, in the shrine of

Jaganath at Puri, one of the most venerated objects of their religion. Nor is this part of the coast without a certain historic interest for Anglo-Indians, for it seems that some of the earliest English sea-ventures to Bengal made their way, not up the Hooghly, but up the Mahanaddi in the direction of Cuttack.

During these three months our programme was hard work from break of day on Monday until the stroke of noon on Saturday, with shooting excursions —for the swamps and backwaters were a paradise for wildfowl, and the scrub-jungle swarmed with deer —on Saturday and Sunday afternoon, whenever possible.

When the ship was sounding out to the 100-fathom line frequent hauls of the trawl were taken, and when she dropped anchor at night the tow-net was always shot overboard and left adrift until the anchor was weighed in the morning. The small hand-dredge was also often used in the anchorages, and lobster-pots were set in many places; so that, by these means, and by occasionally accompanying landing-parties, I was able to make many observations, and good collections of the zoology of the Orissa littoral, to which I shall return in due time. I may, however, mention here that the tale of our successful trawlings in shallow water was twenty-seven.

False Point, where our survey began, is a poor

and capricious harbour, formed by a low sand-spit which has gradually drifted up across one of the deeper outlets of the Mahanaddi river. Town there is none, the only pucca building, which is raised on high foundations of stone out of reach of storm-waves, being the port-office. In the jungle on the sea-face opposite, protected from tigers by a stout wall, is a lighthouse.

The inevitable mound and wooden cross record the fate of a port-officer and his family, who were swept away in the cyclone of 1885, before the present substantial port-office was built.

Besides the port staff and their attendants, the evident population of False Point consists chiefly of Ocypode crabs and little amphibious fishes of the goby family; but we heard many tales of tigers and crocodiles.

We often put in to False Point for coal, and it was here that our seine, which we used sometimes to lay out as a drift-net, was, with its sinkers weighing over 450 pounds, carried bodily away by an enormous shark, round whose remains it was found some days afterwards, tied in a hundred knots, past all surgery.

Between False Point and Puri, a distance of about 60 miles, the coast has nothing to show in the way of civilisation except a few miserable encampments—for they can hardly be called villages—of Oorya fishermen. Though these poor people had hardly a

rag to gird round them, and nothing in the way of property except a fishing-net, a few earthen pots, and perhaps a primitive boat made of rough logs rudely tied together with string, yet they need not be pitied over much, for they have the heritage of the sea—which here is inexhaustible—all to themselves.

Along this piece of coast we had melancholy evidence of the need for a survey, in the shape of six fine sailing-ships lying broken on the shore, four of them having been wrecked in a space of two years. Some say that the currents, which certainly set in very strong hereabouts, were to blame for this; but others think that insufficient use of the lead, the result of undermanning, may possibly have been the cause. It is certain, too, that distances are very hard to judge on a low-lying seaboard, where the only objects to guide the eye are scrubby trees about 15 feet high.

The town of Puri is of such unassuming proportions that the inhabitants, as if fearing to be passed by, have set up its name on a board upon the beach like a railway station; but the domes of the neighbouring temple of Jaganath are conspicuous landmarks for sailors.

We did not see very much of this temple, partly because we were there for work and not for show-gazing, but chiefly because the priests, like Jaques with Orlando, desire to be better strangers with their

non-Hindu acquaintance, and to this end have secluded themselves behind a high wall which may not be approached. A broad road runs northward from the great gate, and ends in an enclosed garden. It is along this road that the devotees drag the car of Jaganath when the god makes his annual visit to his garden-house. For the rest, Puri is full of lodging-houses for the accommodation of pilgrims, and of tanks where the pilgrims cleanse their souls, often at the expense of their bodies' health. At the time of our visit the main streets were replete with mendicants, and the bye-lanes with monkeys.

If we could not come near the temple of Jaganath, we, at anyrate, had no difficulty in seeing the remains of the fine temple of the Sun at Kanárak, about 20 miles to the north-east of Puri. This old ruin, which is black with age, stands all alone in a wide, sandy plain beside the sea. It seems to have originally consisted of two square halls, one of which is now only a mound of fallen stones. The other, which is almost intact, must be over 120 feet high, the walls being about 60 feet from plinth to cornice, and the equally lofty roof being built in overlapping tiers, pagoda fashion, and crowned by a triple dome. In each wall there is a richly-carved doorway, besides which the walls and the roof are one riotous mass of sculptures of gods and men and animals. But, unfortunately, these sculptures have a consistently obscene

tone, which jars horribly with the ideas of people whose notions of sacred architecture have been imbibed under the shadow of the Abbey Church of Westminster.

In the temple precincts, which were silent (except for the chatter of monkeys, and the cooing of pigeons, and the gibbering of disturbed bats), there stand at the four cardinal points, four groups of quaint, colossal statues. Three of them are strangely reminiscent of the Crystal Palace; but on the north is a pair of elephants, which in pose and in every detail of form are faithful unto life, the hand of time having also now given them the proper colour.

Fifteen or sixteen miles to the south-west of Puri is the Chilka lake, which is merely a shallow, marsh-encompassed, narrow-mouthed bay, not quite shut off from the sea by a long, narrow spit of sand. In the winter months it is an ideal place for wildfowl, but they are hard to get at, even with a boat.

Near the southern end of the Chilka lake is the deserted seaport of Ganjam, which was once the headquarters of a district and of a regiment. Its trade has passed away to the little port of Gopalpur further south, and the civil officials and the military have migrated to more salubrious quarters, and all that now remains to Ganjam is a cemetery and a ruined fort.

Our first piece of business before we could begin the survey was to buy a surf boat, for which after-

wards, as the weather grew rougher, we had also to engage a local crew. On this open shore the surf, even in the best weather, is so violent that landing in an ordinary ship's boat is inconvenient or impossible, especially when there are papers and instruments to be taken care of; and even with a surf boat, which is a flabby craft of planks loosely sewn together so as to "give" to the waves, and with a skilled crew who know exactly which wave to wait for, a wetting is no uncommon incident.

Our surf boat was the most rickety old sieve that was ever kept afloat by dint of constant baling, but she could compromise matters with a boiling surf, and did us excellent service. Her crew were accommodated in a little pen alongside my cabin: they were lean and hungry when they joined, but they soon became sleek and shiny on the ship's rations, which included a liberal allowance of that delicious substance, ghee. I would sometimes give them cigars, which they would smoke, holding the lighted end inside the mouth so as to lose no particle of the flavour. When they left us—which they did with much regret, for regular pay and rations on the naval scale are something for an Oorya boatman to remember all the days of his life—they were comforted with half a boatload of empty bottles and jam-tins, in the possession of which they were raised several degrees in the local scale of civilisation.

From the zoological point of view, this quiet three months on the Orissa coast was one of the most eventful periods of my life. When there was nothing else to work at, there were always the tow-net washings, which were rich and varied past all expressing. Out of these I was able to verify many of the known facts concerning the larval forms of Crustacea and the structure and organisation of the Medusæ and Ctenophora. Among the little jelly-fishes of the latter class, two, which I do not think have ever been recorded from the Bay of Bengal, were fairly common; they were species of *Bolina* and *Ocyroe*, both of which are of interest, because, although in all respects they are typical Ctenophora, yet they can propel themselves through the water, after the manner of Medusæ, by the contractions of a pair of lobes which resemble the medusa "bell" or "umbrella" divided.

A shallow, turbid sea, such as this we were working in, where the bottom is for the most part mud, and where the 20-fathom contour-line is from 5 to 13 miles distant from shore, is not an ideal home for zoophytes, but species of the genus *Sphenopus*, which is one of the few sea-anemones that forms for itself a test or protective coat of fine sand-grains, were so common as to lead us to believe that they were gregarious. Another common zoophyte was *Cavernularia obesa*, related to the sea-pens and dead-men's fingers of British seas, which was often

observed to emit brilliant flashes of light when irritated.

Sea-anemones here, for the most part, were found attached to the shells of hermit-crabs, etc., a case of Hobson's choice sometimes, no doubt, but also sometimes illustrating that happy bond of commensalism, or Platonic union, which is one of the most valuable object-lessons for man's edification that marine zoology affords. When two animals of different grades in the zoological scale live together in such a fashion, that each one assists the other in some definite way, while doing it no manner of harm, they are termed commensals, or messmates. For instance, when a hermit-crab and a sea-anemone live together, the hermit-crab, being by nature a very ill-clad and vulnerable animal, acquires by the partnership a thick and easily-adjustable greatcoat, while the sea-anemone, being by nature a hopeless lump of an animal, dependent on chance currents for its food and oxygen, acquires an engine and an intelligent engine-driver all in one, which are always carrying it in the way of the necessaries of life; and yet with this mutual assistance there goes absolute independence in all other respects, such as mistresses and servants, who would both be none the worse for a little knowledge of the principles of zoology, never dreamt of.

In the seas of India we find every gradation of commensalism between zoophytes and hermit-crabs,

ANDERSON'S BLANKET-CRAB.

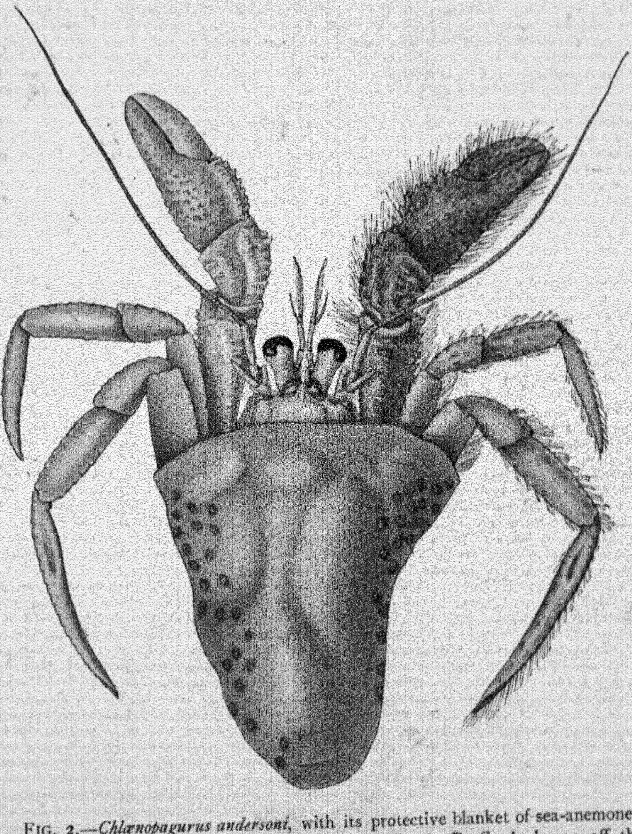

FIG. 2.—*Chlænopagurus andersoni*, with its protective blanket of sea-anemones. This large hermit-crab, which was discovered by Dr A. R. S. Anderson off the Malabar coast, living at a depth of 102 fathoms, does not at any time of life use a shell as a refuge, but is always accompanied by a particular species of sea-anemones.

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from the stage at which a sea-anemone simply fixes itself on to the shell tenanted by a hermit-crab, up to the stage exhibited by the hermit-crab *Chlænopagurus andersoni*, which has no shell at all, but only a blanket formed by the flesh of a colony of sea-anemones.

Besides the hermits, there are found on this coast other true crabs that go partners with sea-anemones; such as the large spider-crabs of the genus *Doclea*, and the little mask-crabs of the genus *Dorippe*.

Fishes sometimes, as numerous naturalists have observed and recorded, enter into partnership with zoophytes. On this coast I often noticed small horse-mackerels constantly using the umbrellas or bells of large jelly-fishes as a shelter, and it was also very common to find a certain kind of fish-fry hiding themselves among the clustering polyps that hang from the floating disk of *Porpita*. But I shall have occasion hereafter to mention very much better instances than these.

The Orissa coast is a famous place for Crustacea of all kinds, and we made a very large collection of them. Among those that specially attracted my attention were, a swimming-crab (*Matuta miersii*), which, when angered or alarmed, could by rubbing its nippers against the edge of its carapace make a noise something like the chirp of a cricket; a buckler-crab (*Cryptopodia angulata*), which at first sight might

almost have been passed aside as part of the shell of a dead bivalve; a mole-crab (*Hippa asiatica*) of gregarious, burrowing habits, whose development I was able to trace satisfactorily; and a bat-lobster (*Thenus orientalis*), whose newly-hatched larvæ I was able to preserve.

We also made a fine collection of the fishes that swarm in such incredible numbers in the estuaries and shoal waters of the Orissa coast. Here, too, we found much that was worthy of observation, such, for example, as the fishes which croak like frogs. It has been known from the time of Aristotle, that many fishes are able to utter sounds which are more or less musical and purposive, and are quite distinct from the meaningless gaspings and gurglings of a fish taken out of water, and many writers have sought to explain the mechanisms by which these sounds are produced. In some cases they are supposed to be caused by grinding together the bones of the pharynx, or by snapping fin-spines in their sockets; in other cases they may, perhaps, be due to rhythmical contractions of the air-bladder, or—in the case of those fishes in which the air-bladder is connected with the gullet by an open duct—by the violent expulsion of the gases of the air-bladder through this duct, somewhat as in coughing. In the case of the two species of sea-perches (*Therapon theraps* and *Pristipoma gouraka*) and of the numerous species of *Sciæna* which

are among the Orissa shore-fishes that have a voice, the noise seems to be made by grinding the bones of the pharynx together, while the air-bladder, which impinges on them, is inflated so as to act as a resonator.

In some of our Orissa fishes the males were decidedly more brilliant in colour, or more highly ornamented in some other way, than the females. This kind of difference between the sexes is a well-known phenomenon throughout the animal kingdom, and has been explained by Darwin as the gradual result, through a long series of generations, of the females of certain species deliberately choosing for mates the handsomest males—just as certain classes of civilised women are said to choose the richest men for husbands. There can be little doubt that where the intelligence is high, as among mammals, birds, and the higher insects and Crustacea, there must be many species whose individuals have both ideas of excellence and sense enough to make choices; and if we do not usually attribute so much æsthetic and discriminative faculty to fishes, it is perhaps because we do not know enough about their habits. When we reflect, however, that there are many species of fishes which display sufficient parental care to build nests, or to incubate their young in some special way, and that there are not a few species which actually bring forth their young alive after the manner of Eve, we shall then, perhaps, be prepared to believe in the existence

of species in which the females are deliberately courted by, and deliberately make a choice of, the males. Numerous writers besides Darwin have discussed this aspect of piscine life, but I may mention here three species of Orissa flat-fishes in which we may suppose that such a courtship takes place. They are *Arnoglossus macrolophus* and *Brachypleura xanthosticta*, in both of which the anterior rays of the dorsal fin form a fine erectile, plume-like crest, of which the female has no trace, and *Rhomboidichthys azureus*, in which the male alone has its forehead adorned on one side with azure blue spots, which gleam like jewels.

But what took the most complete hold of my attention, when working on the Orissa fishes, was the discovery that certain sting-rays (fishes closely related to the sharks and skates) nourish their unborn young on a secretion analogous to milk. Everyone, of course, knows that in the sub-class to which the sharks and rays belong, the females either give birth to living young, or else lay large eggs which, like those of birds and reptiles, are impregnated before they are laid, and are enclosed in a shell. It is well known, moreover, that, where the young are born alive, some species are born with a structure analogous to an "after-birth" attached to them, and some species have no trace of any such structure.* The "after-

* It is, of course, known to serious students of zoology, that the placenta of the sharks is formed entirely by the overgrown yolk-sac.

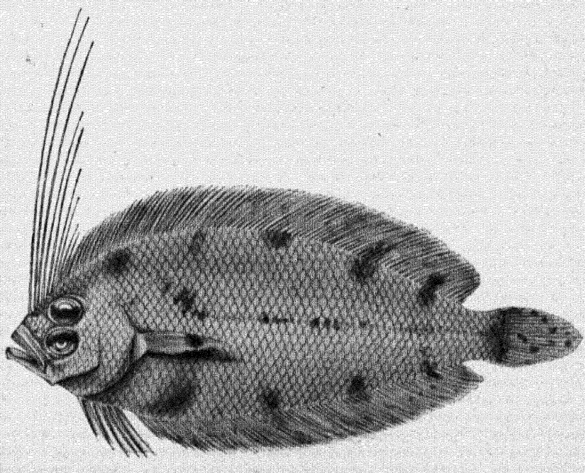

FIG. 3.—Male of *Arnoglossus macrolophus*, showing the ornamental crest of prolonged fin-rays peculiar to the male sex. The specimen figured was captured off the Ganjam coast in 25 fathoms of water.

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birth," we know, is meant to carry nourishment from the mother to the young before its birth, but the exact mode in which the young who have no after-birth are nourished had not been clearly demonstrated. However, from some females of the sting-ray, *Trygon bleekeri* and *Myliobatis nieuhofii*, captured in False Point harbour and further down the coast, in 1888 and 1889, I had the satisfaction of showing that, in these species, the young are nourished before birth by a milky secretion that exudes from special glandular filaments growing on the wall of the mother's womb, the milk, as we afterwards proved, being eaten and digested by the fœtus.

Among other interesting species of fish-like animals that we took off the Orissa coast were lancelets of two species. One of these has recently been described by Dr Arthur Willey as a representative of a new genus which, in allusion to its long præoral lobe, he has named *Dolichorhynchus.* I had a live specimen of *Dolichorhynchus*—not then having any idea of its generic distinctness—under the microscope, and observed that the pulsatile sub-branchial vein, which in the lancelets does duty for a heart, contracted at the rate of about six times a minute.

To sum up my impressions of the Orissa coast, from the zoological point of view: I look upon it as an ideal place for anyone who wishes to study the complete life-histories of the Indian shore-fishes and

Crustacea, and I believe that a Biological Station, established at Puri, would be in the highway of great discoveries.

To speak, finally, of the economic possibilities of this coast, so rich in certain kinds of marine produce and in firewood: I should say that if the regulations of the salt-excise could be modified, and if capital on a liberal scale were forthcoming, it would furnish inexhaustible supplies of dried and smoked fish, fish-oil, isinglass and gelatine for the world in general, and of shark's fins for the China market in particular.

NURSING ARRANGEMENTS OF A RAY.

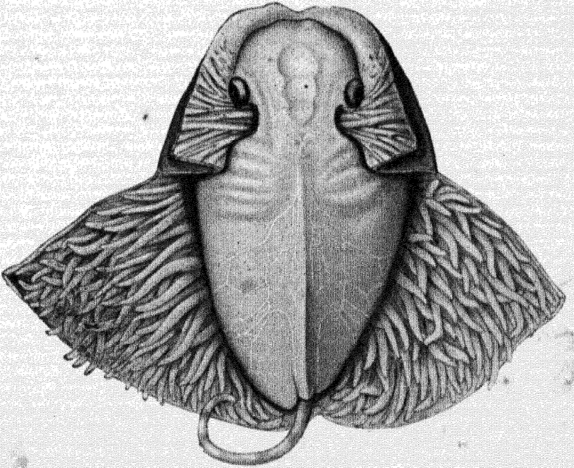

FIG. 4.—Lower part of the oviduct of the Indian Bat-ray (*Pteroplatæa micrura*), laid open to show the unborn young one, and the filaments by the secretion of which the latter is nourished. A large bundle of filaments passes through each spiracle into the pharynx of the immature fish.

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# CHAPTER VI

## SUMMER ISLANDS AND A SUMMER SEA

The Sacramento Shoal. Ingens æquor: the Fauna of the Flotsam: Chameleon Fishes: A Mother Shark and her Young. Station 55: Deep-sea Crustacea. The Western Barrier Reef of the Andamans. The Middle Strait: through Virgin Jungle in a Ship. The East Andaman Archipelago: Land-crabs and Strand-crabs: Shore-going Fishes. Station 56. The Robber-crab of South Sentinel Island: "A very good and restorative Meat." Precocious Orphans: A New-born Family of Turtles. Recrossing the Bay. First Introduction to the Laccadives. Robber-crabs as Fellow-passengers. The End of the Term: Dulce Museum.

AFTER having sufficiently surveyed the coast and anchorages between False Point and Gopalpur, in the course of which undertaking about 15,000 soundings had been made by the ship, and about 30,000 by the launches, the *Investigator* proceeded south to examine a dangerous shoal lying off the delta of the Godávari River, and named, after a frigate of the United States navy which was wrecked upon it in 1867, the "Sacramento" shoal.

In its low-lying swamps and slimy creeks and shallow muddy sea the coast in this neighbourhood is a repetition of the Máhánaddi delta, but on an

exaggerated scale, owing to the larger size of the Godávari and the greater volume of its sediment. As regards possibilities of danger this coast is even worse than the Orissa coast, for the sea is even shoaler and the land even lower and less visible from afar: it is also more frequented by ships, for inside the northernmost spit thrown out by the Godávari delta is Coconáda, one of the principal ports of the Madras Presidency. Two large lighthouses showing powerful fixed lights stand within 11 miles of each other, one on either side of the approaches to the port; but safety in navigation here depends almost entirely on the use of the lead.

The survey of the Sacramento shoal occupied us until the 9th of April, and then we made for Port Blair, to pick up the Andaman boat party which had been left behind in October, preparatory to bringing our sea-work to an end before the onset of the south-west monsoon.

We had a magnificent passage across the Bay from Coconáda, almost due south-east in a straight line, to Cape Bluff on the west coast of Middle Andaman Island, and we utilised it in running a line of soundings between these points. These disclosed the facts, that although within 20 miles of the Godávari coast, the sea-bed shelves very gently, yet between 20 and 60 miles it falls steeply to a depth of 1460 fathoms; and that, from a point within 100 miles of shore, for

a distance of over 400 miles in a south-easterly direction, the bottom of the Bay of Bengal is an almost perfectly level plain, lying between 1654 and 1676 fathoms below the sea-level, having a temperature about two and a half degrees above freezing-point on the Fahrenheit scale, and consisting in more than 300 miles of its extent of almost pure Globigerina-ooze.

Whenever the ship lay-to to sound we had a haul of the tow-net, and whenever a drift-log was sighted a boat was sent away to have a look at it.

These drift-logs are of great interest as being agents in the dispersal of animals, both marine and terrene. What we almost always found on them, besides a crust of barnacles, were two species of grapsoid crabs, one a swimming species named *Varuna literata*, the other a rock species named *Plagusia depressa*. Both these crabs are found in warm latitudes, over the whole extent of the Indo-Pacific shore, and there can be little doubt that their singularly wide range results from their habit of clinging to ships and to timber that gets washed into the stream of the great oceanic currents. It was usual to find shoals of file-fishes hovering round these drift-logs, but with what intent we could not discover, for the stomach of one that we caught and opened was full, not of barnacles, but of the free-swimming oceanic mollusks known as sea-butterflies (*Pteropoda*).

I took particular notice of the extraordinary colour

changes—hardly surpassed by the chameleon—which some of these file-fishes undergo. They are particularly conspicuous in *Balistes maculatus*, which, when swimming in clear water, is blue-black with numerous light-blue spots, but which when concealed in dark, discoloured drift-wood, can occlude its spots and appear as black as the wood itself. A species of *Monacanthus* (I think *M. scriptus*) is perhaps even more chameleonic: one that I caught on a piece of drift was of a dark greenish-black colour, scribbled over with fine yellow lines, but when turned into a white bucket of seawater, the yellow lines gradually expanded until the fish became pale yellow, minutely and sparsely speckled with black. The mechanism of these colour-changes is well known; they depend on the expansion and contraction of certain large skin-cells in which the pigments are imbedded, and the stimulus from the brain which causes the change in size of these cells is awakened by a message from the retina and optic nerve, the whole train of events being an unconscious reflex action much like breathing and swallowing. Their utility is also well understood: briefly, they enable an animal to conceal itself without any sacrifice of its independence or any curtailment of its liberty. If on first thoughts it seems rather unreasonable to suppose that it would in any way benefit a fish to change its colour to that of a drift tree, it must be remembered, first, that we are here only speaking of fishes that

habitually frequent ocean drift; and secondly, that the neighbourhood of ocean drift is so dangerous, by reason of sharks, that this power of concealment must often be of vital moment to fishes that have this habit.

As we lay-to one day, we caught one of these sharks, and found it to be a female, nearly 7½ feet long, of *Carcharias dussumieri*, with ten young ones inside her, each of them 2 feet in length. These we delivered by Cæsarean section, and turned into a tub of seawater, where they swam about with perfect unconcern.

The same day two blue whales, not less than 50 feet long, came within a mile of us, and gave us an acrobatic performance.

We had two hauls of the deep-sea trawl on this passage. The first time the rope gave as we were heaving in and the trawl was lost, but the second time we were successful, and got great store of crustaceans, chiefly of the genus *Munida*, from 480-500 fathoms about 30 miles west of Cape Bluff. All of them had the peculiar boiled - lobster tint which is almost characteristic of crustaceans which live at this depth.

It may here be mentioned that almost all the Crustacea of the deep sea, except perhaps those which are really confined to the abyssal depths, are either crimson or lurid yellow, or some shade between these two colours. The dwellers in the abysses, however, are more often of a chalky tint, either pure or tinged

with red or yellow, but occasionally they are of a smoky purple colour.

At a point some 20 miles west of Cape Bluff we began to cross the South Coral Bank, one of a series of banks that forms a sort of broken "barrier-reef" to the western shore of the Andamans. The water was so intensely clear, and the bottom so marvellously evident, that although we never had less than 9 fathoms beneath us, it seemed to my untrained eye as if we were every moment going to strike. The sea was so unutterably calm that we were able to use the water-glass from the lower platform of the ship's gangway, and we got some wonderful glimpses of submarine landscape.

We passed through from the Bay of Bengal to the Andaman Sea by way of the tortuous Middle Strait, which in certain parts of its course is less than 100 yards wide. How we did it I do not know. I only remember, to begin with, a bewildering maze of firths and lochs of turquoise blue, clusters of high green islands, and gleams of snow-white coral sand, and then the ship suddenly left the sea and plunged into virgin forest. The hills closed up behind us, and those ahead of us showed no trace of an opening; while on either side our yards were almost touching dense, impenetrable jungle through which, as in a trance, we glided on for 10 miles or so, until we ran into an ugly mangrove swamp, and so into the Andaman Sea.

From the 14th to the 22nd of April, we stayed to clear up a few points connected with the survey of some of the straits not far from Port Blair, and this gave me a chance to explore some of the little islands—named after the heroes of the Indian Mutiny—which make up the Eastern Andaman Archipelago. All these islets are covered with dense forest, and their coasts are beautifully varied—bold, sea-beaten cliffs and tunnelled headlands alternating with beaches of hard coral-sand strewn with cuttle bones and shells of the pearly nautilus. They are fringed, especially to the eastward, with coral-reefs, between which and the shore are lagoons which at low water are, to a naturalist, more desirable than the Elysian fields.

Landing in the early morning, with a couple of lascars to carry my collecting gear, I would all day long ransack the reefs or cut through the jungle, as the state of the tide ordained; and at evening, weary, wet, sunburnt, and ragged as a beggar, I would go back to the ship, having seen sights and brought away stuff that would supply me with facts and fancies for the rest of my life.

Though I never came across any Andamanese, I once saw a kitchen-midden of ashes, shells, and bones of fish, turtle, and dugong. I saw no mammals except bats, and not many birds and insects. But the jungles were full of great land-crabs of the species *Pelocarcinus humei* and *Cardiosoma hirtipes*, and of

great and small hermit-crabs of the genus *Cenobita*, which no doubt take the place of insects as scavengers on small tropical islets. *Pelocarcinus* and *Cardiosoma* would be seen crouching under dead logs, waiting for the friendly shades of night, but the Cenobites seem to be active throughout the twenty-four hours. Another species of land-crab that lurks about these jungles is *Geograpsus grayi.* Though all these crabs have large functional gills, they also have the lining membrane of the gill-chamber much thickened, to enable them to breathe air.

The rocks on the seashore are the haunt of multitudes of crabs of the species *Grapsus grapsus* and *Grapsus strigosus.* These crabs are exceedingly difficult to catch: they run very fast, and can dodge and double like a hare; their bodies are so thin and flat that they can squeeze into the narrowest crevices; and the claws in which their legs end are burred with spines, so that they can cling to any surface, however steep; they keep such constant watch that one can never surprise them; and even when you think that you have succeeded in cutting off their every chance of escape, they hurl themselves headlong into the sea and disappear.

Even more hopeless to pursue are the little goby fish of the genera *Periophthalmus* and *Boleophthalmus*, which one constantly meets in the mangrove swamps here, as in all tropical parts of the Indo-Pacific.

AN AMPHIBIOUS FISH.

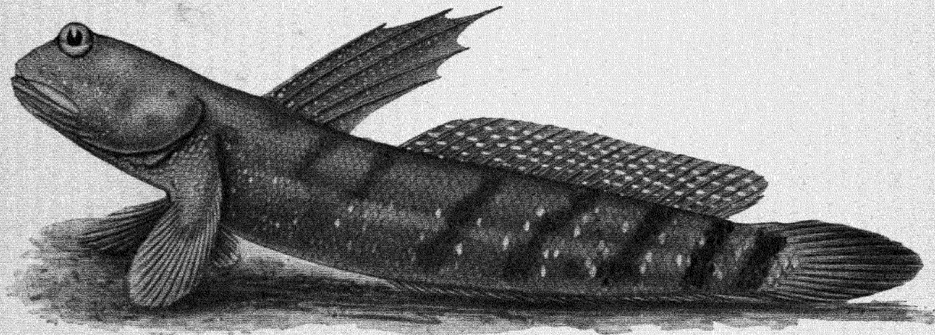

FIG. 5.—*Boleophthalmus boddaertii.* One of the common shore-going gobies of Indian creeks and estuarine mud-flats.

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Though they are typical fish and breathe by gills, they have a passion for the land, and during the daytime may always be seen ashore, especially where the coast is muddy, basking in the sun, or hunting for food, raising themselves on their fleshy pectoral fins, as a man, whose legs are paralysed, might use his arms. When pursued, they take great springs, using their tails and ventral fins for the purpose; and if they cannot escape into the sea, they will dive down a crab's burrow, or dash into a bunch of mangrove-roots. They, too, are excessively wary, having eyes like swivels, which they never seem to close.

Among other interesting inhabitants of these islets are species of edible-nest-building swifts, whose nests, with eggs and young in them, were abundant in the sea-caves at the time of our visit.

Having taken on board our boat-party, which consisted of Lieutenant M. H. Smyth, R.N., and Lieutenants St L. S. Warden and W. G. Beauchamp, R.I.M., we left Port Blair on the 23rd April, *en route* for headquarters at Bombay.

We passed through Macpherson's Straits, where wooded heights, rising abruptly to 1400 feet, bound a narrow strip of sea of heavenly blue, and then at a station midway between North and South Sentinel Islands, in 240-220 fathoms, we sounded and dredged. The haul was entirely successful, and yielded many kinds of sponges, corals, starfishes and sea-urchins,

sea-worms, and Crustacea, and a few species of mollusks and fishes, all of great rarity.

Afterwards we landed on South Sentinel, a little solitary islet not one square mile in extent, which, small though it is, is of special interest as being one of the few spots in Indian seas where the giant hermit-crab, *Birgus latro*, is found. Though the weather was perfectly fine, and the open sea quite smooth, yet there was quite enough surf breaking on the steep and open beach to make landing a matter of some trouble. In the clear, deep water close to shore, we saw shoals of porpoises and turtles, but fortunately there were no sharks, as we had to land in water nearly neck deep. The island seems to be nothing more than a coral-reef raised a few feet above high-water mark, for loose coral rock crops up everywhere, and even in its very centre we found masses of coral whose specific structure was still quite plainly recognisable. It is covered with huge forest trees, but except for a thin belt of screw-pine near the shore, there is no undergrowth, so that the jungle, unlike that of most tropical islands, is easy and surprisingly pleasant to walk in. The principal inhabitants of the island are turtles, which only land at night to lay their eggs; huge water-lizards (*Varanus salvator*), as big as young crocodiles, which seek their prey upon the reefs, and bask upon the burning beach; and land-crabs of many sorts, which rule the jungle.

The king of these land-crabs is *Birgus latro*, a true hermit-crab, but of a size too gigantic to fit into any empty mollusk shell, after the usual habit of its tribe. Being independent of a shell, its "tail," or abdomen, instead of being soft and spirally-twisted, as it is in most hermit-crabs, is straight, and is clad dorsally with hard plates of its own. Being practically an air-breather, it also differs from most other hermit-crabs, which are water-breathers, in the nature of its breathing-organs; for although, like the majority of hermits, it has fourteen pairs of gills, these are of very small size, and breathing is chiefly effected by spongy, vascular, arborescent growths, or warts, of the lining membrane of the gill-chamber. It is also very massively built, but except in these few particulars, it does not essentially differ from the common soldier-crab of British shores. Its proportions may be imagined from the statement that a good-sized male weighs between 5 and 6 pounds, and is over 1 foot long, and nearly 8 inches in extreme breadth, that its largest nipper is nearly 1 foot long, and nearly 8 inches in girth, and that the span of its longest legs is over 2½ feet.

*Birgus* is found in all the warmer parts of the Indo-Pacific, but in our locality it seems to have been exterminated everywhere, except on the Nicobar Islands and on South Sentinel. Its specific name, *latro*, or robber, is derived from tales of its climbing coconut

palms to steal the nuts. This seems to be a mistake, though it certainly does eat fallen coconuts when it can get them, tearing away the husk, and hammering open one of the eyeholes of the shell with its large nippers, and then extracting the pulp with the small hinder pair of nippers, in the way described by Darwin. On South Sentinel there are—or were in 1889—no coconuts, and the only abundant fruit was that of the screw-pine.

The sight of these curious monsters crouching beneath the roots and clinging to the buttresses of the trees in this gloomy forest was weird enough for Gustave Doré. We captured and bound about twenty of them, and afterwards carried them on board alive. They made but a feeble resistance, striking out with their strong second pair of legs, and not using their nippers at all.

It must surely have been *Birgus latro* to which Master Francis Fletcher refers in his account of Drake's voyage round the world. The *Golden Hind* had grown foul with her long voyage, and her water-casks were much decayed, so Drake took advantage of a secluded and uninhabited little island south of Celebes, at which to repair ship. Here he landed his men, and after strongly entrenching himself, pitched tents and set up a smith's forge and a charcoal factory, and here he remained for twenty-six days until all defects were made good. The party found

THE ROBBER-CRAB OF ORIENTAL ISLAND JUNGLES.

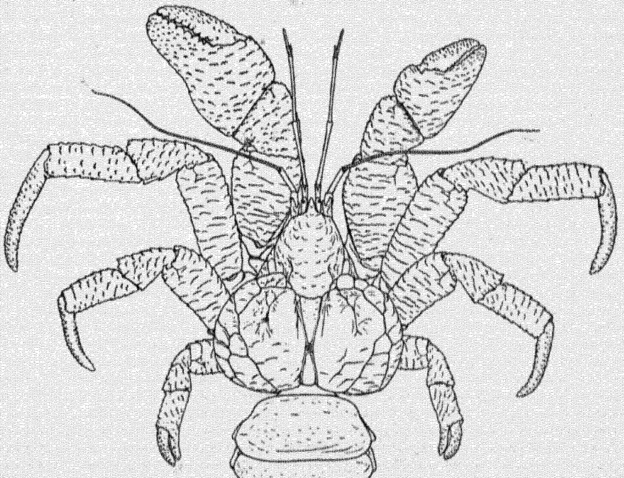

FIG. 6.—Male of the Robber-crab (*Birgus latro*), about one-sixth the natural size. The small and slender fifth pair of legs are tucked up, out of sight, in the branchial chambers. The specimen from which the drawing was made weighed nearly six pounds. It is in a conventional attitude.

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"many rare and admirable creatures," among which they could not "omit to speak of the huge multitude of a certain kind of crayfish, of such size that one was sufficient to satisfy four hungry men at a dinner, being a very good and restorative meat; the special means (as we conceived it) of our increase of health. They are, as far as we could perceive, utter strangers to the sea, living always on the land, where they work themselves earths, as do the conies, or rather, they dig great and huge caves under the roots of the most huge and monstrous trees, where they lodge by companies together. Of the same sort and kind we found some that, when we came to take them, did climb up into trees."

Other land-crabs besides *Birgus latro* inhabit the jungles of South Sentinel, namely, the great *Pelocarcinus humei* and a species of *Cardiosoma*. In both these species, though the gills are large and functional, the thickened lining membrane of the gill-chamber plays an important part in respiration.

On the beach of South Sentinel we were fortunate enough to witness the entry of a brood of turtles into the world. There was a tremendous commotion in the dry sand, and out of it there emerged a swarm of little objects, looking like beetles, which all with one consent made for the sea. Even when we caught them and started them off in the opposite direction, some unerring instinct caused them at once

to turn round towards the sea again, as other observers in other lands have described.

From South Sentinel we crossed the Bay of Bengal to Colombo, taking soundings on the way. The deepest of these, near the middle of the mouth of the Bay, showed a depth of 2035 fathoms, a temperature (after correction for pressure) of 34° Fahr., and a bottom of pure Globigerina-ooze.

Rounding Ceylon and Cape Comorin we proceeded to Bombay, stopping on the way at Anderut and Kiltán in the Laccadive archipelago, to check the meridional distances of those two islands from Bombay.

All the Laccadive islands appear to be the remains of eroded atolls, raised only a few feet above the sea-level, and formed entirely of coral rock and coral sand. They rise quite abruptly from a sea that within half a mile of shore is often close upon 1000 fathoms deep. Small though they are, they are thickly inhabited, the population of Anderut—an island but 2 miles long and only a few hundred yards broad—being (in 1889) over 4000 souls. The people, who are Mahomedans with some remarkable survivals of primitive pagan customs, live chiefly by the cultivation of the coconut, the husk of which they macerate and beat-out into *coir* for the Malabar market, where they exchange it for rice and salt, and cloth, and other simple necessaries of life. They also do a little deep-

sea fishing; and, of course, as their trade is all by sea, they are accomplished boatbuilders. On some of the islands they grow lilliputian patches of grain and sweet potatoes and starch-yielding aroids. Their drink is water drawn from shallow wells, which are carefully walled in, and faced with stone down to the water-line; and they live in huts built of roughly-dressed coral stone, and thatched with palm leaves. They have a few cows and goats and fowls and cats, but they cannot bear dogs, and will have none of them. They are not bothered by any wild animals larger than rats, which, however, do damage to the coconuts. Land-crabs of the genus *Geograpsus* are common near the houses, and, of course, cenobites are found everywhere. Away from the shore, the only animals, besides these, that I saw on Anderut were crows, lizards of the genus *Calotes*, a few small frogs, two species of freshwater snails, a water-beetle, and some dragon-flies; and on Kiltán, a warbler, some grasshoppers and butterflies, and a spider. I do not know what the political institutions of these islands are, but I believe they are governed, directly or indirectly, by the magistrate of Malabar. At the time of our visit, the British Government was represented at Anderut by a stout clerk with an umbrella, and at Kiltán by a *chaprassi* with a brass badge. At Anderut there is a school where English is taught: we saw it at the peaceful hour of noon, when the

headmaster was taking a no doubt well-earned nap on its sandy floor. At Kiltán there was a great deal of sickness; so that, for pity's sake, I had to give up my idea of collecting on the reefs, and to open a medicine shop instead. The most general complaint was subacute ophthalmia, of which the exciting cause was no doubt the awful glare from the snow-white coral beach. Rheumatism was also very common, and I saw some dreadful ulcers, and leprosy was in painful evidence.

I must not forget to mention that during this part of the voyage we learnt something of the habits of the robber-crabs that we had brought away from South Sentinel. During the day, unless the weather were cloudy, they hardly moved, but after dark they were active, and every night some of them would escape from their cage and climb about the ship, much to the consternation of the watch. They fed chiefly at night, and were shameless cannibals; though, whether they killed their victims, or only ate the bodies of those that died a natural death, we did not make out. I was much astonished to see one of them drinking from a runnel of rainwater, by dipping its fingers into the water and then putting them into its mouth in the same grotesquely school-boy fashion that crabs commonly adopt when eating.

On the 13th of May the *Investigator* made fast

in Bombay Harbour, and before many days most of the men were paid off, and most of the officers departed to their monsoon quarters at Poona, there to prepare the season's survey-work for publication. I went into recess quarters at the Indian Museum in Calcutta, where I stayed until October, working at the fishes which had been collected during this and previous seasons. The results of this work were published in the *Journal of the Asiatic Society of Bengal* for 1889 and 1890, and in the *Annals and Magazine of Natural History* for November and December 1889.

I take great pleasure in recording here my deep obligations to Dr Günther's *Introduction to the Study of Fishes*, and *Catalogue of the Fishes in the British Museum*, which were two of the works that I found in my little laboratory on joining the *Investigator* at Port Blair. Thanks to their aid—so clear, so concise, and so coherent—I was able to make my first ventures along the steep and thorny path of systematic zoology with some courage and confidence.

## CHAPTER VII

### "MANY ISLES AND MANY FULL STRANGE PLACES"

A Vain Search. An Apostle among the Laccadivians. The Fauna of Coral Shingle. *In patenti prensus.* Diamond Island and the Gulf of Martaban. Rangoon: Pagodas and Philosophers. The Tree of the Ten Utilities. *Insulæ Fortunatæ:* the Coco Islands: The Sights and Sounds of the Reefs.

ON the 28th October 1889, the *Investigator* left Bombay in pursuance of her ninth annual programme, which was, to carry a boat-party to survey the Bassein River (one of the mouths of the Irrawaddy), stopping at Port Blair in the Andamans to pick up the necessary boats and tents; to commence, while detained in that neighbourhood, a survey of the Coco Islands; and then, when the weather on the Coromandel coast could be relied on, to cross over the Bay again and take up the survey of that coast at the point where it had been left off the year before.

Captain Carpenter's five-year tenure of the appointment having expired, the survey was now in charge of Captain R. F. Hoskyn, R.N., and besides the Royal Indian Marine officers of the previous season, we had on board Lieut. F. Dobson and Mr H. A.

Livermore; but we were poorer by the loss of Lieut. E. J. Beaumont, who had for a time attained that height of a sailor's ambition, a shoregoing billet.

On our way southwards, in addition to running the usual soundings between Bombay and Colombo, we took observations for checking the position of Kalpeni Island in the Laccadives, and spent some time in searching for a shoal which the captain of a Dutch mail-steamer had reported to be lying in the Nine-degree Channel, right in the way of traffic between Colombo and the Red Sea. The supposed shoal proved to correspond with Euclid's definition of a point, for where it was said to exist we could find nothing less than 1100 fathoms of water. Our deepest sounding between the Laccadives and the Malabar coast gave 1420 fathoms, but later observations show that this tongue of the sea has a maximum depth of a little over 1500 fathoms and a minimum bottom-temperature of about 35° Fahr. The bottom consists on the Malabar side of dark mud brought down by the streams, succeeded as we go westwards, first by green sand, and then, as the islands are approached, by a grey, calcareous ooze, formed partly of shells of Foraminifera, but chiefly of fine coral detritus.

Kalpeni, to which we were able to give one afternoon, is really a copy of Anderut and Kiltán; but as we saw it just after, instead of just before, the south-west monsoon, it showed up better than the

other islands. It is about 4 miles long and about half a mile broad, and it forms with the adjacent islet of Cheria the eastern arc of an atoll, of which the western arc is a submerged reef. As on all the Laccadives, the coconut palm is the staff of life, but here we also saw little fields of rice and millet of some sort, and small gardens in which grew plantains, limes, papayas, pán, and chilies. The wells were much frequented by a pretty land-crab of the genus *Geograpsus*, and besides the common Calotes lizard, I got a gecko and a skink. The people complained much of the rats, which destroyed the young coconuts, and asked me about a remedy: I recommended cats, but they said that cats would not climb palm trees; then I advised them to import some owls, but they declined to have any dealings with such ill-omened fowl.

On our way to the Bay, as we skirted the southern coast of Ceylon, we dredged in 32 fathoms. The bottom hereabouts consists of coral shingle, and this is one of the best spots that I know of in these seas for anyone who wants to collect solitary corals of all sorts, and Polyzoa, and Crustacea. Among corals, you will get here plenty of *Flabellum* and *Eupsammia* and *Rhodopsammia*, and of crabs you may take thirty or forty species in a single haul. Most of the latter are small, and many of them combine a lethargic and cataleptic habit with such a curious colouring and

A GOOD CASE OF PROTECTIVE RESEMBLANCE.

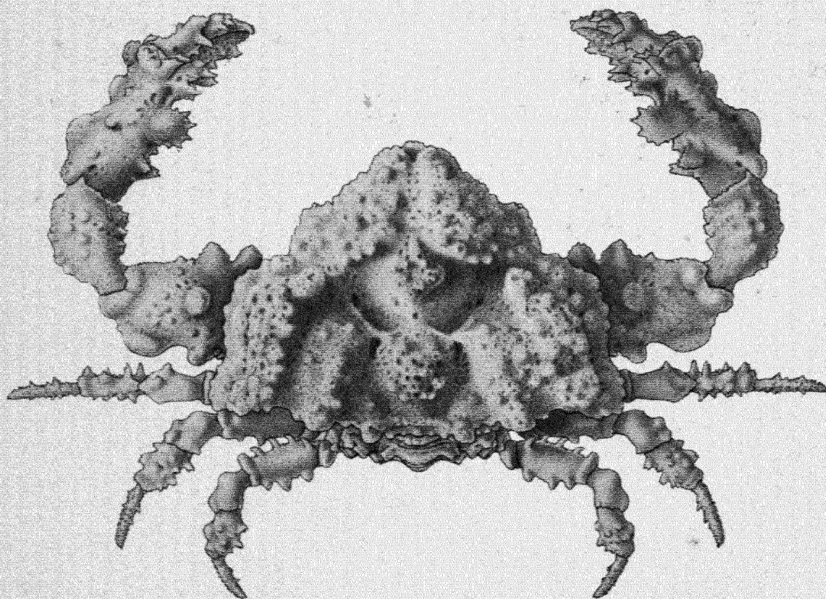

FIG. 7.—*Parthenope investigatoris*, an Oxyrhynch crab that lives among coarse coral shingle, and is itself so scored and pitted as to resemble a piece of worm-eaten coral. The last pair of legs has been accidentally broken off, and the animal is shown in a conventional attitude.

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A NATURALLY-PROTECTED CORAL-CRAB.

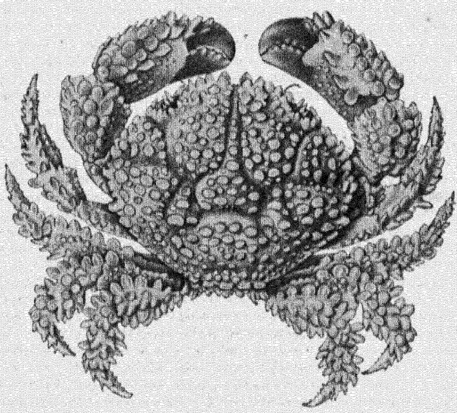

FIG. 8.—*Actæa flosculata*, enlarged four times. A small Cyclometope crab found in coral shingle off Ceylon, as well as off the Maldives.

The whole of its upper surface is closely covered with knobs and petal-like spines, which make it, in its native habitation and in its natural attitude (it is here represented conventionally), a very inconspicuous object.

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sculpture, that they are hard to distinguish from the bits of dead, worm-eaten coral amid which they live. So perfect in some cases is this protective disguise, that you may even find growing on them the same calcareous sea-weed and the same branching Foraminifera (*Polytrema*) with which dead coral is so commonly encrusted. The most perfect disguise of this sort is attained by *Oreophorus reticulatus*, *Parthenope investigatoris*, *Carpilodes cariosus*, and *Actæa flosculata*, all of which you may find here. The fishes, too, include several species of small flat-fishes so curiously dappled and mottled as to defy detection as they rest on coral shingle: one of the most perfectly concealed species of the Ceylon coast is *Samaris cristatus*, whose effective toning surpasses description.

On our passage from Ceylon across the Bay we got into the wake of a cyclone, which gave us so much to do that no thought of dredging or sounding ever entered anyone's head, and we were very glad when we found ourselves safe in Port Blair harbour.

Diamond Island, where at length we dropped our boat-party, is a little sandstone islet, covered with jungle, at the entrance of the Bassein River, populated only so far as is essential to the upkeep of a pilot-house, a telegraph-station, and a small meteorological observatory. It is a great breeding resort of turtles, and the Burmese who farm the eggs objected that

our boat-party would frighten all the turtles away: it is also said to be a peculiarly favourite resort for cobras.

From Diamond Island we went to Rangoon for coal, stopping on the way to dredge in the Gulf of Martaban. The fauna of this muddy gulf has distinct affinities with that of northern temperate seas, especially those of Japan, as will be realised when I mention that among fishes, *Monocentris japonicus* and a true Ray are met with, and that among crabs we find such forms as *Homola* and *Latreillia*, and such characteristic Japanese species as *Carcinoplax longimanus* and *Charybdis miles.*

At Rangoon, the chief object of attraction is the great Shwedagon Pagoda of Buddhist fame. As you ascend the river, you see its golden pinnacle flaming on the horizon long before any signs of a town are visible. It stands on a high, terraced mound at the northern end of the city, and is approached by a long flight of stone steps, all worn and polished by the bare feet of many generations of pilgrims. The steps are guarded at foot by a pair of huge stone griffins, and are flanked on either side by a long tier of little pagodas and booths, where worshippers can buy flowers and tapers for offerings; so that they form a sort of terraced arcade, made very dear to fancy by the rich carving of the wooden roofs of the pagodas. As you linger here you see before you

the whole immemorial drama of the unchanging East: Lazarus with his bowl, and the dogs licking his sores: Dives, with fair, round belly lined with ghee: Mary Magdalene tripping along unabashed, with a rose for her favourite shrine: John the Baptist and Elijah the Tishbite, with matted hair and hollow eye and scanty raiment, straight from preaching and fasting in the wilderness: besides all the seven stages of the ordinary man. At last you reach the sacred acropolis, in the centre of which, towering above a splendid chaos of little shrines, is the great pagoda itself—a solid pinnacle of more than 300 feet, part pyramid part spire in idea, glittering with a coat of gold, and crowned by a jewelled *hti* or pontifical umbrella: all round the *hti* are bells, so that when the wind blows it makes a mysterious music. Eight of Gautama Buddha's hairs are said to be embedded in this pagoda.

More interesting than the great pagoda are the little pagodas that cluster in scores round its base. Their roofs are a perfect wonder of the woodcarver's art, and their inner colouring of crimson and gold has a very majestic effect. Most of them contain colossal images, in rows and phalanxes, of the Enlightened One sitting cross-legged in a mysterious brown study. One gazes spellbound at these bland, monotonous embodiments of the supreme indifference—*τὰ ἀδιάφορα.* Some of these little pagodas are filled by gigantic bells,

which when gently struck—horns and beams of wood are used for the purpose—pour forth a flood of melancholy murmurs.

There is no solemn hush about religion here. Believer and every kind of unbeliever, devotee and holiday-maker, children and loafers, and dogs, are all mixed up in one crowd as in the bazár, the Buddhist apparently holding the stoic belief that true religion depends on an inward state, and not on any outward circumstance.

> "A governed heart, thinking no thought but good,
> Makes crowded places holy solitude."

After Hindu Pharisaism and Mahomedan fanaticism, to say nothing of all the schisms of Christianity, there is an air of almost unreality about a temple into the holy places of which, and at the hour of prayer, every man and woman, no matter what their creed or honest doubt, may come just as they are and do just what they please. It maybe, as Marcus Aurelius and Hamlet said, that there is nothing either good or bad, but thinking makes it so; but until I went to the Shwedagon Pagoda, I never heard of priests and congregations who acted in this belief at their own altars.

From Rangoon of blessed memory we departed to the Coco Islands, which, as has been already mentioned, are interesting as being the only islands of

the Andaman group where the coconut palm is found growing in a state of nature. Why, when this is the case, these happy isles should be uninhabited, when the coconut palms of the dangerously-exposed Laccadive archipelago support a considerable population, is one of those mysteries that no doubt admits of an easy explanation. We who live in great cities in an age of shoddy and steam-power, are apt to forget the potency in human affairs of plain, raw produce such as coconuts: let us, then, pause and read what one of the earliest of European travellers in the East, Ludovico di Varthema, writes, though incoherently and not entirely correctly, about the power of the coconut palm:—

"I will describe another tree to you, the best in all the world, which is called *Tenga*, and is formed like the trunk of a date tree. Ten useful things are derived from this tree. The first utility is wood to burn; nuts to eat; ropes for maritime navigation; thin stuffs which, when they are dyed, appear to be made of silk; charcoal in the greatest perfection; wine, water, oil and sugar; and with its leaves which fall off they cover the houses, and these ward off water for half a year. Were I to declare to you in what manner it accomplishes so many things you would not believe it, neither could you understand it. The said tree produces the above-named nuts in the same manner as the branch of a date tree; and each tree will

produce from 100 to 200 of these nuts, the outer part of which is taken off and used for firewood. And then, next to the second bark there is taken off a substance like cotton or linen flax, and this is given to workmen to beat, and from the flower stuffs which appear like silken stuffs are made. And the coarse part they spin, and make of it small cords, and of the small they make large cords, and these they use for the sea. Of the other bark of the said nut excellent charcoal is made. After the second bark the nut is good to eat. The size of the said fruit is at first that of the little finger of the hand. When the said nut begins to grow, water begins to be produced within; and when the nut has arrived at perfection, it is full of water, so that there are some nuts which will contain four and five goblets of water, which water is a most excellent thing to drink, and is also like rosewater, and extremely sweet. Most excellent oil is made from the said nut, and thus you have eight utilities from it. Another branch of the said tree they do not allow to produce nuts, but they cut it in the middle and give it a certain inclination; and in the morning and evening they make an opening with a knife, and then they apply a certain fluid, and that fluid draws out a certain juice. And these men set a pot underneath and collect that juice, of which one tree will produce as much as half a jug between the day and the night. This they place over the fire and

boil it one, two, and three times, so that it appears like brandy, and will affect a man's head by merely smelling it, to say nothing of drinking it. This is the wine which is drunk in these countries. From another branch of the said tree they produce in a similar manner this juice, and convert it into sugar by means of fire; but it is not very good. The said tree always has fruit either green or dry, and it produces fruit in five years. As to the goodness of this tree, when the kings are at enmity one with another, and kill each other's children, they nevertheless sometimes make peace. But if one king cut down any of these trees belonging to another king, peace will never be granted to all eternity."

On our way to the Cocos we trawled in 41 fathoms, hitting a marvellous foul bottom that tore the trawl to pieces, but did not hurt the swabs, in which great numbers of sponges and corals and starfishes and sea-lilies were entangled. From out of these we picked a host of little, timid crustaceans, many of which were protectively coloured. Most remarkable of all were two little hermit-lobsters of the genus *Galathea*, one striped like a wasp, with violet and blue, and living on a sea-lily striped in exactly the same fashion; the other white, with pink spots, and living on a white and pink sea-pen.

From the 2nd to the 9th December I was marooned on Great Coco Island, in company with Dr Prain

of the Calcutta Botanical Gardens, who had been invited to join us at Rangoon. We had with us a tent and a servant, a jolly-boat and two lascars, and a venerable native botanical collector. We pitched our tent in a clearing on the top of a little hill at the north end of the island, having beneath us on our landward side a pleasant pool of fresh water fringed with long grass and water-gentian, and covered with red lotus, and on our other three sides the far-resounding sea.

There is on this island a herd of wild cattle—the feral descendants of domestic cattle that were brought to Table Island, close by, for the service of the lighthouse—and these we looked to for beef; but in vain, so that we had to fall back on Crosse and Blackwell, pasturers of the people. From the pool, however, we got some oceanic teal, and from its sedgy banks an occasional snipe. Hardly was our tent pitched, than there came up out of the jungle, to guard it, a very ancient and weather-beaten pariah dog of the female sex. She had probably been left, like Robinson Crusoe, by some people who once upon a time took a lease of the island and made an unhappy attempt to settle on it. Pariah dogs, as a rule, have an instinctive dislike of Europeans; but this poor creature was so glad to see men again, that she cared not whether they were brown or white.

Our week on the Great Coco is one of my

happiest Indian memories. We rose at the break of dawn, and all day long we roamed our happy hunting-grounds on the reefs or in the jungle, and at night, after nodding over a pipe under the stars, we slept past power of poppy and mandragora and all the drowsy syrups of the East. But yet we averted Nemesis, by yielding ourselves patiently to mosquitoes and sandflies: these and the thorns of the jungle soon brought us to a state of general itchiness quite such as Thersites desired for Agamemnon in the play.

I set down my observations of this island knowing that they are of little more value than impressions, seeing that it is a hard thing to observe on a great scale in a place where one has to make his way through tangled jungle with a hatchet in one hand and a compass in the other, and with mosquitoes screaming at him and biting him all the time. It is a narrow strip of land, between 7 and 8 miles long and perhaps 3 half-miles broad, encompassed by coral-reefs, whereon day and night the "league-long roller" thunders perpetually. Its surface is rather steeply undulating, the highest ridges reaching to nearly 200 feet above sea-level. The prevailing rock is a hard and compact sandstone, with occasional extremely thin seams of crystalline limestone, and in places a fine breccia-conglomerate occurs. The whole island is covered with a dense and gloomy forest, made impass-

able by a thorny tangled undergrowth of calamus and other creepers; but in places where the rock crops out there are open patches of coarse grass, and near the shore there is a pleasant fringe of coconut palms, cycads, and screw-pines, carpeted by the convolvulus (*Ipomœa biloba*), which in these tropical islands binds the loose sand and shingle together, and always helps "the firm soil win of the watery main." This open belt and the dry part of the beach beyond it is one crawling mass of little hermit-crabs (*Cenobita*), adapted, like the robber-crab, for a life on dry land. When alarmed, they slip hurriedly into their shells and drop motionless as if dead, so that the noise of their fall makes a continuous tinkle as you walk: they very soon invaded our tent, where they might be heard falling about any time of day or night. I once found one of them busy, like a large bee, among the florets of a coconut, which made me wonder whether they may not sometimes play a part in fertilizing flowers. Moseley, in his *Notes of a Naturalist on the "Challenger,"* has recorded the finding of a cenobite on a bush 4 feet high, at the Admiralty Islands.

In the thick jungle you find cenobites of larger size, and great land-crabs (*Cardiosoma hirtipes*), of a beautiful dark violet colour with scarlet nippers. Though crabs are more in evidence than anything else, there are other animals on the island besides the herd of feral cattle. The Andaman pig is said to live

here, though we saw no sign of it, and there are at least three species of snakes, two of which are vipers (*Trimeresurus gramineus* and *purpureo-maculatus*). There are birds, of course, and the most characteristic sounds of the island, after one becomes accustomed to the distant thunder of the reef, are the mocking chuckle of the koel, and the soft bellow of the fruit-eating pigeon. With so many crabs, it is not strange that insects, except mosquitoes, are not very numerous; but as there are plenty of bright yellow-and-black spiders of the genus *Gasteracantha*, there must be a store of insects for them to feed upon.

Dr Prain concerned himself almost entirely with the botany of the island, while I found most employment in the lagoon, where I made a large collection of sea-stuff, among which were a new species of fish and several new species of crabs. After a time one becomes aware that these lagoons have a fauna of their own, an assemblage of animals of retiring or stealthy habits, whose colour-markings are such as attract no notice against a background of coral rock. Under almost every rock, for instance, you may find a sea-perch, *Epinephelus hexagonatus*, whose livery of dark, close-set hexagonal spots has a decided resemblance to the surface of an Astræid coral: you cannot get this fish to leave the protection of the rock; so much so, that a large specimen which Dr Prain and I wounded (and afterwards landed success-

fully), went straight to its doom in a clump of coral, when it might have betaken itself to the open sea beyond our reach. Another fish most exquisitely fashioned for a life among reefs is the rock-perch (*Pterois volitans*), with its body branded and mottled like an encrusted rock, and its long fin-rays bedecked with streaming filaments that sway and wave like fronds of seaweed: it can change colour, too, like a chameleon, and though its ordinary hues are ever-varying shades of brown and red, yet one that crept away from me into a deep blue pool became all blue in alternate darker and lighter cross-bands.

Sticking on every rock here you will see a number of little hemispherical sponges, and when you pick one off, you will find beneath it, like a limpet in its shell, a small crab (*Cryptodromia pileifera*): most of the members of the family to which it belongs have the same habit of sheltering themselves under some other small animal. Lurking in every pool you will find the stealthy swimming-crab (*Thalamita crenata*), which—until you touch it and it darts away like a fish—you might easily mistake for a marbled stone. Then again, there are several species of shrimps that live among the tentacles of a gigantic, blue-spotted sea-anemone, and, like it, are spotted and banded with blue, so as to be invisible as long as they keep to its shelter.

Although, no doubt, the theory has at times been

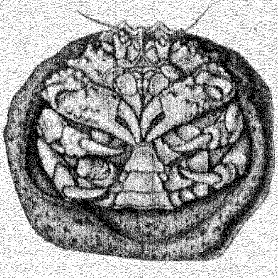

FIG. 9.—*Cryptodromia pileifera*, with the commensal sponge beneath which it shelters; seen from the under surface, and enlarged three times. The last two pairs of legs, by which the sponge-cap is held in position, are not visible in this view.

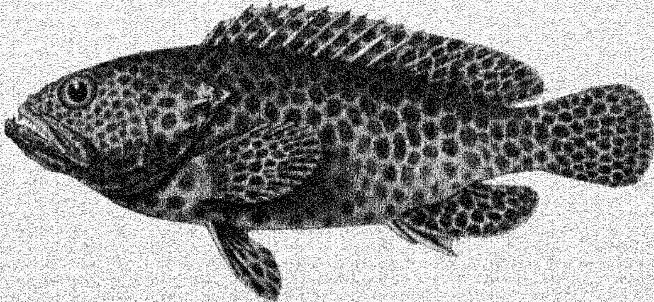

FIG. 10.—*Epinephelus hexagonatus*, the common Coral-perch of the Andaman Islands, much reduced in size. The colour-markings of this fish render it very inconspicuous against a background of certain kinds of growing coral.

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somewhat strained, yet there is plenty of satisfactory evidence to show that while certain species of animals are, like soldiers in khaki, saved from their enemies and disguised from their victims by being coloured in tone with their immediate surroundings, there are, on the other hand, animals of a certain sort that are protected from molestation, like lepers, by being marked in some conspicuous manner. These "warning-coloured" species are commonly nasty, and the theory is that by being obtrusively marked, they are, after one or two painful lessons, left severely alone by enemies who might otherwise try to eat them. A few of these unpleasant individuals must, of course, from time to time fall victims to the curiosity of inexperienced enemies, but the result is beneficial to the species as a whole, for every individual that is killed will give to that enemy of the species a lesson which will not soon be forgotten. At least one instance of what I think must be warning colouration may be noticed on the reefs of Great Coco Island. It is a little species of sea-snail (*Bulla*), whose coat of emerald green, spangled with bright orange spots, attracts the eye like a meteor; but it has a most pungent and disgusting smell of musk, which, I fancy, must make it quite uneatable. Some that I collected and put in my stock pickle-jar gave all the contents a most unpleasant and enduring taint.

The reefs have sounds as well as sights of their own, mysterious cracks and pops that seem to come from nowhere. They are caused by little shrimps of the genus *Alpheus*, which live hidden, usually in pairs, among the sponge and coral. These Alphei are remarkable for the gigantic size of one of their large nippers, on one of the blades of which there is a big tooth which, when the nippers are closed, fits tightly into a hole in the other blade. The sound is said to be made either by the sudden opening of the blades and forcible extraction of the tooth from the socket, like a cork from a pop-gun, or by the sudden closing of the blades and sudden forcing of the tooth into the socket, like a wad into a gun-barrel. Another crustacean that makes a sharp clicking sound is *Gonodactylus chiragra*, one of the locust-shrimps. It has, instead of nippers, large "raptorial feet," in which the terminal claw folds down, like the blade of a penknife, into a groove cut in the whole length of the joint behind it. At the near end of the latter joint, at a point corresponding with the tip of the closed blade of the penknife, is an erectile spine, and the noise which this animal makes seems to be produced by causing the blade of the knife (terminal claw) to fly open, and to strike the erected spine as it does so. The large rock-lobster (*Palinurus striatus*), which one finds in these lagoons, is able to make a weird, creaking noise by rubbing a

special process of the base of its antennæ against a special raised facet on either side of its head; the mechanism being exactly the same as that of its European relative, which has been described by Professor Möbius.

# CHAPTER VIII

## A CHAPTER OF ACCIDENTS, EXPLANATIONS, AND DIGRESSIONS

An Unsuccessful Deep-sea Mission. On the Ganjam Coast: *In terrâ domibus negatâ*. Corals and Sea-worms as Messmates. Retiring Crustaceans. Venomous Fishes. A Digression on Warning Colours. A Musical Prawn. Remarkable Fishes: *Callionymus* and *Bembrops*: Fishy Explanations. A Partnership of Polyps and Fish: *Minous inermis* and Co. Self-negation in a Brahminy Duck. A Digression on the Feelings and Emotions of Birds. The Pulicat Shoal. Deep-sea Dredging *en route* to Bombay.

ON the 9th December, the *Investigator* left the Cocos for Gopalpur. Crossing the Bay we encountered occasional drift-wood, upon which we found the usual population of crabs (*Varuna literata* and *Plagusia depressa*), shadowed by the inevitable swarm of file-fishes. We also took some deep-sea soundings, and had one very exciting haul of our new reversible "Blake" pattern trawl. This was right in the middle of the northern end of the Bay, in 1439 fathoms, the bottom being brown mud, of a temperature of 35.3° Fahr. Instead of leading the dredge-rope through a hawsehole in the bows and a block pendant from the bowsprit, we this time tried the experiment of

fixing our tackle to the yardarm. But in hauling in, it carried away, and down came block and dredge-rope with a fearful crash athwart the fore-awning chain. Luckily the rope, though nearly cut through, held until we got some fresh tackle on to it; but no sooner had we again commenced heaving in, than the drum of the steam-winch, over which the rope was being reeled, gave way, striking the deck with great violence, but fortunately not doing much harm to the bystanders. When at last the trawl came in, amid a dreadful tangle of ruined dredge-rope, all the swabs were gone, and all we got for our trouble was a little mud and three crustaceans, which had probably been caught in the ascent of the trawl. We had sent down in the trawl-bag an untouched bottle of Bass's beer, and when it came up, though the capsule and wires were intact, the cork was so much compressed that it rattled in the neck of the bottle, and the bottle itself contained a mixture of beer and sea-water. The pressure at a depth of 1439 fathoms, amounting to nearly two tons on the square inch, had been sufficient to turn the cork into a pellet of hard wood and to force the sea-water under the capsule, and so between the mouth of the bottle and the shrunken cork.

On the 14th of December, the *Investigator* reached the east coast of the peninsula, and there we stayed until the end of March following, and surveyed nearly 140 miles of the Ganjam and Vizagapatam coast-line,

from Gopalpur to Bimlipatam. Unfortunately this coast is of very moderate interest. Away 20 miles and more in the background are the Eastern Gháts, whose natal beauty is not entirely concealed by verdure, and whose peaks, some of them, attain a height of nearly 5000 feet, and look very fine in a cold weather sunset. But the shore itself is as dry and bare as the Sahara. Mile upon mile of drifting sand, broken occasionally by a muddy creek with its treacherous fringe of swamp, and the diurnal alternation of the land and sea breeze make up the conditions of life upon this dismal coast. For vegetation, there is the creeping convolvulus (*Ipomæa biloba*) with its leathery leaves, the trailing "sea-pink" grass, the screw-pine, and occasional groves of coconut palms: for animals, there is the red Ocypode crab (*Ocypoda macrocera*), with its mortal foes the jackal and the Brahminy kite: for sounds, there is the everlasting thunder of the surf. As for man, there are a few villages of poor fishermen, who, however much or little they may regard the scriptural exhortation as to meat and drink, certainly take next to no thought wherewithal they shall be clothed. There are, indeed, a few small ports, such as Barwa, Calingapatam, and Bimlipatam; but such annals as they have belong, for the most part, to the past, when the French and the Dutch still had hopes of an Indian dominion, and they are now of little interest except to the student of early

Anglo-Indian history. At least, these were my impressions twelve years ago, but since then the new East Coast Railway may have brought them into the working-day world again for all I know.

Gopalpur, whence our survey started, is a clean and pretty little town peeping out of a sombre grove of casuarinas, which were planted, partly to check the inland drift of the sand, and partly to make the place more conspicuous from the sea. Some man of sanguine imagination and good intentions once formed the design of fitting the port with a pier, like a first-class English watering-place; but when he had run the pier out into the very worst part of the surf he repented him of his undertaking, and left it to the waves as an object of perpetual derision. On one of the hills to the north-west of the town is a ruined fort, without a name or a history, and a few miles to the south is a vast *jheel*—formed by the insidious spread of sand-dunes across the mouth of a feeble stream—which affords winter pasture to innumerable migratory wildfowl of every kind.

The sea that washes this coast is shallow, the 100-fathom line being from 18 to 23 miles from shore; but it is fairly clear, and therefore is not nearly so rich in surface life as the muddy sea further north. In the course of three months, however, we managed to get together a very good collection of animals of all sorts, and I propose to devote this chapter to an

account of some of the more interesting among them.

On the submerged pinnacles of rock which one here and there encounters along this part of the coast, we found Madrepore corals growing; not the massive reef-forming species, but delicate encrusting and arborescent forms like *Dendrophyllia* and *Cœnopsammia.* We also dredged in some abundance little "solitary" corals of the genera *Heterocyathus* and *Heteropsammia:* these corals are shaped something like small thick disks, in the base of which there is usually embedded and concealed a dead mollusk shell which serves as a house for an active little Sipunculoid worm. I kept some of these corals alive in my small aquarium, and watched how their lodger-worm, by thrusting out one end of its muscular body as a lever, was able to whisk them about from place to place. It is, in fact, as pretty an instance of commensalism, or association for mutual benefit, as is known, and it has attracted the attention of numerous naturalists.

We noticed numerous other animal partnerships, which might have been cases of commensalism, but were more probably merely one-sided adaptations of one animal standing in need of protection to another animal capable of affording the required protection without any expenditure of effort. For instance, a very common branching zoophyte of this region is *Spongodes pustulosa* (or some very closely related

A CERTAIN CONVOCATION OF POLITIC WORMS AND CORALS.

FIG. 11.—*Heteropsammia aphrodes*, from off the Ganjam coast, 20-25 fathoms. The left-hand figure shows the base of the coral, with the opening for the messmate worm; the right-hand figure gives a view of the interior of the cup of the coral. Both figures, of course, represent merely the skeleton of the coral, from which the animal has been removed by maceration; twice the natural size.

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species), a creature near akin to the "dead-men's fingers" of British seas. It looks like a small "run-to-seed" cauliflower, of which the individual florets are of a bright pink colour. Hidden among its branches we found no less than four small species of crustaceans (an *Alpheus*, a *Galathea*, a *Porcellana*, and a rare little spider-crab known as *Hoplophrys oatesi*), all of which, in life, are greyish-white with bright pink spots, so that they are perfectly invisible so long as they remain quiet in their living refuge. Another zoophyte that we often dredged was *Pteroeides elegans* (or a species intimately close to it), one of the sea-pens, of a grey colour profusely marked with little, blackish rings. In its leaves three small species of crustaceans are accustomed to hide, all of whom are coloured and spotted exactly like the living citadel in which they dwell. I have already mentioned the sea-lily (*Actinometra*) striped in alternate bands of yellow and purple, on whose fronds similarly-striped crustaceans live without fear of detection: here we found the same sea-lily giving secure shelter to sea-worms, banded yellow and purple like itself.

On this part of the coast I made my first acquaintance, under very painful circumstances, with a cat-fish named *Plotosus arab*, which is found in all Oriental waters from the Red Sea to Polynesia. It is, when young, of a rich purple-brown colour, with two bright yellow bands running along each side of the body,

something like a hornet striped fore-and-aft instead of crosswise, and it is a very conspicuous object. There can be little doubt that the glaring colours of *Plotosus arab* act as a warning-signal, for this fish also resembles a hornet in being able, with the large barbed spine of its dorsal fin, to inflict a venomous wound, causing great pain and serious consequences. No doubt there are a good many other species of cat-fishes, not in any way conspicuous for their colouring, which can inflict nasty wounds with the spines of their dorsal and pectoral fins; but within my own experience, none of them have the same venomous potency as *Plotosus arab*, whose virulence may be appreciated when I mention that a wound inflicted in my fore-finger, by a little individual not 3 inches long, made my arm numb and useless for several days, although remedies were applied without any delay.

As has already been observed, the signal colours by which many dangerous and offensive animals are distinguished are not supposed to have been acquired on altruistic principles for the benefit of the world at large. Whether or not, like all rationally-utilised self-regarding acquirements, they do profit the world in general is another question; but they are believed to have originated, in the first instance, for the sole advantage of the said dangerous and unpleasant species themselves. Individuals of these odious species must, of course, occasionally perish by violence; but this,

for the species as a whole, is the very conclusion of the whole matter, since every individual that comes to an untimely end at the hands of an enemy gives that enemy a lesson not to meddle with other individuals of the like kind. Moreover, it is also probable that, through the subtle power of "association," animals that have once or twice suffered by molesting any one kind of glaringly-coloured offensive animal will begin to have a general suspicion of all glaring colours.

"Till old experience do attain,
To something like prophetic strain."

Speaking for myself, I know that, having many times suffered, I now use great caution in handling animals whose colours at all resemble those of a "blazer," especially if the colours be yellow and black. A burnt child dreads the fire: and no reasonable argument can be adduced why the higher animals, whose mental powers are not enormously inferior to those of very young children, should not learn by a single painful experience. As a matter of fact, every one practically admits this in the training of domesticated animals, who are broken in, like unruly children, by punishment, and if we only use our eyes we can see the same thing going on in the stern school of Nature.

For instance—if I may just this once make a rather serious digression—I at one time owned a young Himalayan bear, brought in by hillmen straight from his mother's lair, and thenceforward, until he went

across seas to the Zoo, allowed to live an almost free and natural life (except that he sometimes had treats of lemonade, and was occasionally experimented on with a cigar) in a large garden. For food he had fruit and vegetables and rice, and every evening as a peculiar treat I gave him a few grasshoppers. Now there is a grasshopper of this country whose colours at once proclaim with emphasis that, like Socrates among men, it is not like its fellows. Instead of being green or brown as most grasshoppers are, so as to avoid being seen, it is black, with lurid red crossbands on its body and glaring yellow blotches on its fore-wings, so that it is about as conspicuous an object as a harlequin would be at a funeral. When you touch it, it begins to dribble out a pungent evil-smelling froth, and then you begin to suspect that its colours are meant to advertise this unpleasant fact to all whom it may concern. At anyrate, I resolved to see if my little bear's interpretation of the matter accorded with my own, so one evening I offered him one of these "blazer" grasshoppers, whose name I may mention is *Aularches miliaris.* One smell was enough to make him turn his upper lip inside out in the most comical way. In a short time I again offered him the insect, and then he stood up on his hind legs and smacked it out of my hand with his paw in exactly the same way as he used always to treat the offer of a lighted cigar. I several times afterwards brought

him an *Aularches miliaris*, and the mere sight of the insect was enough to make him try to shuffle off: but if I insisted on his facing it, he would knock it out of my hand with a hearty cuff, and if I had forced it into his mouth I have no doubt he would have bitten me. I suspect that the cat-fish *Plotosus arab* is avoided by other fishes who have reached years of discretion much as *Aularches miliaris* was avoided by my young bear.

I made numerous sections of young decalcified specimens of *Plotosus arab*, but in no case could I find any trace of a special poison gland connected with any of its spines, so that the venom must be contained in the ordinary slime of its skin. Of the numerous other species of fishes that can inflict poisonous wounds with their spines, some, as Dr Günther has shown, are provided with special poison glands for this purpose, while in others, such as the dangerous tribe of sting-rays, the ordinary secretion of the skin appears to be sufficiently virulent. I regret to say that I did not, as I should have done, examine the fresh mucus to see if it contained any large amount of soluble albumin: I recommend this inquiry to any naturalist who may meet *Plotosus arab* in its native element.

I have already referred to the voluntary and apparently purposive sounds emitted by *Alpheus*, by certain locust-shrimps and rock-lobsters, and by the

swimming-crabs of the genus *Matuta*, and I have now to introduce a stridulating prawn, which we dredged in 33 fathoms of water off the Ganjam coast. In prawns, as everybody knows, the tail ends in a large five-bladed fan, which, besides being the principal organ for swimming, is also a weapon of defence. The pointed middle lobe of the fan is the terminal segment of the body, and is known as the *telson;* the two pairs of broad, lateral blades are the greatly-expanded "legs" of the penultimate segment of the body, and are known as the *caudal swimmerets, inner* next the telson, and *outer* farthest from the telson. In our stridulating prawn, the edges of the telson and the inner edge of each inner caudal swimmeret are finely burred like a rasp, so that when they are rubbed upon one another, a soft, thrilling sound, like the subdued note of a grasshopper, results. The prawn repeatedly made this noise, which sounded and felt like the preparations for an explosion, when held in the hand.

I propose to give in another chapter some account of the fishes found in the great depths of this part of the coast, and to speak here only of a few species, interesting from three different points of view, that live either in shallow water or quite close to the 100-fathom line.

The first of these is the spangled dragonet (*Callionymus lineolatus*) who tells us an eloquent story

on the little known theme of courtship and wooing among fishes, a class of animals who are regarded as proverbially cold-blooded and impassive. An interesting account of the courtship and pairing of the European dragonet (*Callionymus lyra*) has been published by Mr E. W. L. Holt, in the *Proceedings of the Zoological Society* for 1898, along with a fine coloured plate of the male in the attitude of entreaty. Mr Holt's observations, which amplify and correct those of previous observers, show that the males do actually display their charms before the female with great emotion, and that the female can, if she likes, make a deliberate choice from among her rival suitors. The living male of *Callionymus lineolatus*, to be found off the Madras coast, is one of the most beautiful fishes that I have ever seen. Its head and body are an indescribable mingled harmony of many shades of brown and blue and green, set off with light blue spots and pearl-coloured stripes; the anterior dorsal fin, which can be erected like a high sail, is golden-yellow, studded with many white-edged blue ocelli; the tail fin is a blend of brown and yellow, set with turquoise spots; the belly fin is like dark-blue velvet sown with rows of turquoise; the pelvic fins are like golden-green satin, fringed with dark blue, and spangled with small turquoise spots; and the pectoral fins are of a delicate lavender-grey, with serried dark-brown spots. The female is but a dishclout in respect of him.

Among the lower animals, when the sexes differ greatly in colour, it is almost always the male that is the more splendid. But in *Callionymus carebares*, another of the dragonets of the Coromandel coast, the female is more brightly coloured than the male, a fact which can only be understood on the supposition that in this species the *rôle* of the sexes is reversed in courtship, and that it is the female who makes the first advances. This reversal of parts, accompanied by a reversal of characters both physical and mental, is known to be the case with certain exceptional birds, such as the painted snipe, the button quail, and the cassowary, in all of which the female is more showy and more pugnacious than the male; but it has never before, so far as I know, been illustrated from the biology of fishes.

Interesting, for quite another reason, is a fish of the family *Trachinidæ* (Weevers), known as *Bembrops caudimacula*, which belongs to the fauna of the 100-fathom line off the Madras coast. This species, which is a ground-fish, was first discovered in Japanese waters, and received its name at the hands of Professor Steindachner, in 1877. Three years afterwards it was again discovered, but was not recognised, on quite the other side of the world, off the *Atlantic* coast of the United States of America, and was again described as a new species by the late Professor Goode, under the name *Hypsicometes gobioides*. When,

## TWO NOTABLE FISHES OF THE INDIAN FAUNA.

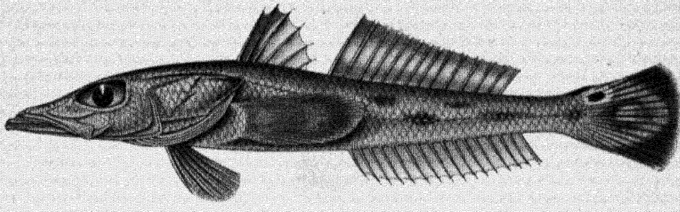

FIG. 12.—*Bembrops caudimacula*, from off the Coromandel coast, 128 fathoms; half the natural size. The same species is found in Japanese seas, and also off the Atlantic coast of North America.

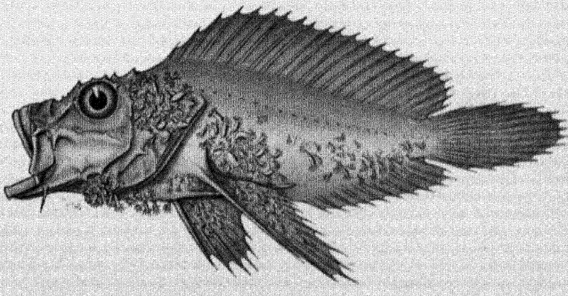

FIG. 13.—*Minous inermis*, with its coat of commensal polyps (*Stylactis minoi*). This fish, always encrusted with the polyps, has been found in several places off the Indian coast, from the Máhánaddi to Calicut, in depths of 45-150 fathoms.

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several years afterwards, it was found by the *Investigator* off the Madras coast, it was a third time described as new, and named *Bathypercis platyrhynchus*. But we afterwards recognised it as being identical with the fishes previously described by the Austrian and American professors. Seeing that it is an undoubted ground-fish, its occurrence in three regions so utterly remote as the Gulf of Mexico and neighbouring coasts of the United States, the Bay of Bengal, and the seas of Japan, requires some special explanation. My own opinion is that the curious range of this fish, which is by no means an isolated instance, can only be explained by the assumption of a continuous sea and shore connecting these points at some former geological period.

Another fish of this coast, remarkable in quite another way, is the little rock-perch (*Minous inermis*). The rock-perches (*Scorpænidæ*) almost all either creep about on the sea-bottom or hide themselves in the crannies of reefs, where, by reason of their mottled lichen-like colouring, and by a profusion of wavy cutaneous filaments with which their body and fins are decked, they are difficult to distinguish from shingle and rocks encrusted with seaweed and zoophytes. Instead of frond-like filaments of its own, *Minous inermis* is more or less invested with living hydriform polyps: these always belong to one and the same species (*Stylactis minoi*), and the fish has

never yet been found without a coat of these polyps, nor have the polyps ever yet been seen anywhere but on this particular fish. The polyps are not parasites, as is proved by the facts, first, that they have a mouth of the proper form, and tentacles of the proper size and number wherewith to catch their own prey; and secondly, that numerous individuals can always be found crammed with food, which must have gone in at their mouth. It is not the sordid bond of parasitism but the happy tie of commensalism which unites these two animals so very wide apart in the scale, and while the fish constantly carries its polyp-friends to pastures new, the polyps in return help to conceal the fish from the watchful eyes of its foes.

I have already spoken of the *jheels*—formed by the blocking of the drainage of the land by drifting sand-dunes—which occur all along this coast, and the wildfowl that haunt them during the winter months. One afternoon, when I was shooting on the banks of one of these *jheels*, I witnessed an act of bravery and devotion on the part of a Brahminy duck that, I think, is worthy of record. A flight of these wary birds passed overhead, giving me a long shot, which winged one of them and brought it fluttering down, luckily for itself, into the water instead of on to hard ground. As soon as the rest of the flock noticed the accident they all with one consent stopped and hovered, and

finally one noble individual flew down and settled by its wounded mate. Of course I did not put forth my hand against them again. Such instances of self-sacrifice on the part of gregarious animals lower in the scale are particularly interesting to the evolutionist, who is always on the lookout for the hidden origins of his own humanity, and for evidences of that touch of Nature which makes the whole world of mind, as well as of body, kin. And as I have already in this chapter been guilty of one digression in order to point a moral, I may as well amplify this case of the Brahminy duck by relating a few more instances—all observed by myself in Calcutta—of bird-behaviour in which the ethical element is plainly apparent.

My wife and I have for more than three years kept an English song-thrush and a grass parrakeet (*Melopsittacus undulatus*) together in an aviary along with many other birds. From the first the parrakeet evinced a strong admiration for the thrush: it would sit all day long at the thrush's feet, drinking in every note that the thrush uttered. As in the case of Bill Sykes' dependents, its affection was proof against all ill-treatment; for although the thrush would constantly chase it away, and peck it until the feathers flew thick, it would always come back and sit enraptured by the side of the scornful object of its choice. Finally, it has taken to singing to itself, in gentle undertones, a song in which all the thrush's

notes—especially the characteristic and beautiful chord-like strains—are most distinctly recognisable.

We once had in our aviary a pair of zebra-finches (*Tæniopygia castanotis*) whose love for each other, even amid a crowd of affectionate couples of avadavats, was remarkable to behold. They were literally inseparable both in action and in repose. The aviary is in a large open wind-swept verandah, where the air is as pure as that of the field, so that we very seldom have a death from disease; but unfortunately something went wrong with the hen zebra-finch, and she died. After her death, the poor unhappy little male sat mourning for a week, in the little chosen corner where he used to nestle beside his mate, and then he too died. Of course, it may be said that he had caught some infection from his dying mate, but in that case there ought to have been some spread of the disease among the thirty other little finches living in the same cage; which there was not.

Here is another incident showing that birds like human beings, know what love and constancy and grief are. In a pond in our grounds we keep a few wildfowl, and among them there was once a pair of black coots (*Fulica atra*). We are accustomed to feed them every morning with grain and bread, but otherwise—except that they are pinioned—they live under almost natural conditions. One morning the coots, who had always been particularly eager about

the bread ration, were not present at feeding-time, and at first we fancied that they had somehow managed to escape. It turned out, however, that only the female had disappeared—for which, perhaps, rats were responsible—and that the male was moping among the reeds. And there for many days he continued to pine, letting the feeding-hour pass unnoticed, though in time he completely recovered. There is an interesting sequel to this case. Some weeks afterwards a new mate was provided for him, whose acquaintance he was by no means anxious to make, although in time the pair became friendly. The new female was not pinioned, but only had her wings cut. When her new quills were grown she—probably having recollections of her own to influence her—flew away, and the old male, who had so deeply mourned his first mate, was not in the least upset by her departure.

If monogamous birds are so often patterns of conjugal fidelity and devotion, they can also be guilty of a foolish inconstancy. The following case illustrates both sides of the question in a very curious way. Among our cage-birds is a very handsome little male avadavat of the common kind (*Sporæginthus amandava*), who wooed and won a mate of his own species. For more than a year the pair lived happily together, spending most of their time in making nests and vainly endeavouring to hatch-out eggs. But when some female orange-breasted wax-bills (*Sporæginthus*

*subflavus*) were put into the cage, the inconstant little husband at once appropriated one of them. His first mate, however, refused to give him up, and the final result was a *ménage à trois*, which has already lasted for a year, and has been productive of a nestful of eggs in which all three partners showed equal interest, though their joint efforts to hatch the eggs were not successful.

The survey as far as Bimlipatam was completed by the end of March, and as there was still nearly a month of fine weather in prospect before the approach of the monsoon should put a stop to work, the *Investigator* conveniently filled in the time with an examination of the Pulicat shoal some few miles north of Madras, which was said to be extending seawards.

On the way down we had several hauls of the trawl, in depths ranging from 840 to 1310 fathoms, the result of which will be referred to in future chapters. One very calm day the sea between Madras and Pulicat was thickly covered, as far as the eye could reach, with a sort of floury, yellow dust, each speck of which, under the microscope, was found to consist of from 50 to 60 tiny threads of Diatoms, every thread being made up of about 100 individuals.

After ascertaining that no material changes had taken place in the Pulicat shoal, it was time to be thinking of the return voyage to Bombay, in the

course of which we managed to get two highly successful hauls of the trawl, near the Laccadives, in 740 and 1000 fathoms. In one of them we dredged up over 200 specimens of a large and beautiful "solitary" coral (*Caryophyllia ambrosia*) of a species previously unknown: in the other the most remarkable discoveries were two species of crustaceans which till then had been regarded as characteristic of the depths of the Gulf of Mexico. One of these was *Bathynomus giganteus*, a gigantic member of the wood-louse order (*Isopoda*), but exceeding the wood-louse in size as the ox does the frog, since it attains a length of 12 inches and a breadth of 4 inches: the other was the blind lobster, with long, rake-like nippers, named *Phoberus cæcus*. I need not enlarge upon these hauls here, as I think it will be more convenient to give a concise account of the entire deep-sea fauna brought to light by the *Investigator*, in a separate series of chapters.

On the 7th of May, after more than six consecutive months of work at sea, the *Investigator* reached Bombay. I passed the recess at the Indian Museum, where the late Professor Wood-Mason and I spent several happy months together examining and describing the deep-sea collections made during the season. The immediate results of our labours were published in the *Annals and Magazine of Natural History* for 1890 and 1891. Owing to the kindness of Rear-Admiral Sir John Hext,

R.N., who was at that time Director of the Indian Marine, I was enabled during this recess to engage a native artist to figure all the new species of animals discovered by the *Investigator*.

I may here add that, during the season of which this chapter is a partial record, we made thirty-six successful hauls of the trawl in the shallow waters off the Ganjam and Vizagapatam coasts, and came to the conclusion, that although to the zoological collector these coasts, owing to their somewhat greater variety of physical feature, are perhaps more interesting than the Orissa coast, yet, that from the economic point of view, the latter coast, where the prevailing estuarine conditions are peculiarly favourable to fish life, is much the more promising.

# CHAPTER IX

## ANOTHER VISIT TO THE ANDAMANS

Dredging off the Laccadives: A Mollusk and its Commensals. A Sad Tale of the Sea. Dredging across the Bay: Strange Messengers from the bottom: The Torch-bearers of Pluto. A Second Visit to Great Coco Island: Growth of Coral-reefs: Birth of an Islet: Natural Fish-traps: A remarkable Lizard. Little Coco Island: Raised Coral-beaches: *Sus andamanicus*: Voracious Water-lizards: A new-formed Lake.

It was on the 15th of October, in the year of our Lord 1890, that the *Investigator* left Bombay on her tenth, and my third, surveying voyage.

The main features of her programme were to resume the survey of the Coco Islands where it had been left off the year before, and then, when the Coromandel coast should become practicable, to continue the survey of that coast from Bimlipatam as far southwards as possible. The officers with the ship were, Commander R. F. Hoskyn, R.N., commanding, and Lieutenants Searle, Warden, Mathias, Huddleston, and Kendall, R.I.M., assistant surveyors.

Between Bombay and Colombo, inside of the Laccadives, we had four hauls of the trawl in depths

ranging from 738 to 1091 fathoms; on all four occasions the bottom brought up was "green sand"; the lowest bottom-temperature touched was 37°.5 Fahr. One of these hauls considerably damaged our gunner, Mr Peterson, who, when the trawl was being hove in, got his hand foul of the wire-rope in an attempt to pick off the remains of some pelagic creatures that were sticking to it. Luckily the lascar at the winch was a sharp and experienced man, and reversed at once, so that our zealous gunner escaped with a bad cut and a few bruises, instead of having his arm torn off.

The results of these hauls consisted for the most part of starfishes and mollusks of many kinds. Among the latter was a handsome *Pleurotoma*, which we named *P. symbiotes*, or "the partner," because the outside of its shell was encrusted along both sides with small sea-anemones of the genus *Epizoanthus*. That this association of the two animals is no accidental circumstance, but is a definite alliance for mutual benefit, is proved by the facts, first, that we have not found these sea-anemones on any of the other numerous species of *Pleurotoma* dredged in these seas; and secondly, that on several subsequent occasions when this *Pleurotoma* has been taken, it has always had this particular *Epizoanthus* upon its shell.

Very boisterous weather betided us at and from Colombo, and as we were fighting our way round

A DEEP-SEA MOLLUSK AND ITS MESSMATES.

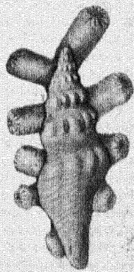

FIG. 14. — *Pleurotoma symbiotes*, with its commensal zoophytes (*Epizoanthus*), from off Cape Comorin, 1043 fathoms. This animal, unlike other Indian Pleurotomas, has never been taken without a crust of these sea-anemones.

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Dondra Head, the man on the lookout reported a boat in distress right ahead of us. It proved to be an overturned catamaran, with two men clinging to the broken outrigger, so we hove to, and lowered a boat and picked them up. One of them, quite a youth, was too exhausted to move; but the other, who was an old man, had sufficient strength to climb up the gangway without any assistance, and to exhibit dumb transports of gratitude that would have softened a heart of stone. We clothed them in suits of blanket-cloth, and laid them out to dry on the warm grating of the boiler-room, and gradually restored them with stimulants and hot soup, until at last they were able to speak. Then the old man told us that he and three other men from a small village between Galle and Dondra Head had, four days before, gone afishing, and had been blown out to sea by a storm, which broke their outrigger, and so capsized their frail catamaran; that for two whole days they lay tossing in the sea, exposed to the fury of wave and wind and rain, their anguish being increased by the fact that they were right in the track of trade, and were frequently passed unnoticed by steamers whose attention they vainly endeavoured to attract; that at first one and then another of his mates had dropped off exhausted, and that his remaining companion was just about to succumb to fate when the *Investigator* bore down upon them. This tale was corroborated by the

state of the skin of these two survivors; for though they were brown men, their skin, by prolonged maceration, appeared white, and the whole thickness of the epidermis was peeling off in great flakes. We landed them in a little inhabited bay near the Great Basses Lighthouse. Captain Hoskyn allowed them to keep the blanket suits, the pockets of which he caused to overflow with ships' biscuit; we also collected a few rupees for them on board, to compensate them in some measure for the loss of their boat and fishing-gear, and to carry them safely home.

From Ceylon to the Coco Islands our course lay nearly north-east across the *ingens aequor* of Bengal. Though on this passage we had a good deal of foul weather, we managed to take several soundings and to get three hauls of the trawl, one of them in the great depth of 1997 fathoms, and another in 1644 fathoms.

The bottom, at 1997 fathoms, in the middle of the Bay, was pure Globigerina-ooze, with spicules of siliceous sponges, and (brought up in the trawl) waterworn pebbles of pumice: the temperature at the bottom, corrected for pressure, was 35° Fahr.

At 1644 fathoms, exactly 100 miles to the west of Middle Andaman Island, the sample of the bottom brought up by the sounding-tube was calcareous ooze, but in the trawl there were some fragments of rude earthen pottery and numerous decomposing leaves,

A SHINING LIGHT OF THE DEEP SEA.

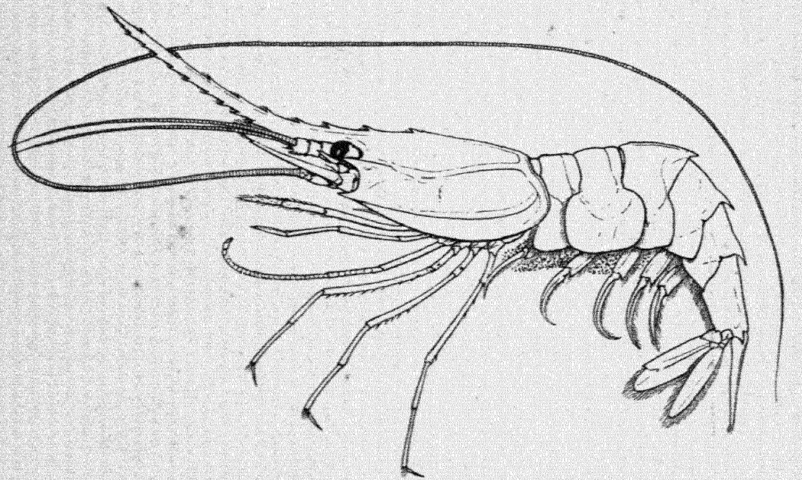

FIG. 15.—*Heterocarpus alphonsi*, a brilliantly-luminous deep-sea shrimp found in all parts of the seas of India at depths of 500-740 fathoms. The phosphorescent fluid is emitted from the base of the second pair of antennæ.

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which had certainly come from the bottom. This is a fact of special interest, as it shows how, even in places far remote from continents and rivers, land-derived vegetable matter suitable for the support of animal life, may find its way into the abysses of the sea.

The animals dredged up from these great depths were, for the most part, sponges and starfishes and other Echinoderms; but in the haul in 1997 fathoms we also got a long-stalked sea-squirt (*Culeolus*), and a shrimp (*Pontophilus abyssi*) with degenerate eyes, which had previously been known only from the depths of the North Atlantic; and among the stuff from 1644 fathoms were specimens of the widely-ranging deep-sea hermit-crab (*Parapagurus pilosimanus*), which lives in a house formed by a colony of gristly sea-anemones.

Our third haul, in 561 fathoms, to the west of the Coco Channel, was of special interest, as it threw some light on a dark subject; namely, the means by which certain deep-sea animals are able to illuminate the gloomy depths in which they live. Everyone, of course, knows that many marine animals can give out flashes of light, and indeed it seems more than probable that the majority of the inhabitants of the sea are more or less luminous. Of those that are obviously brilliant, the animals that contribute to the nocturnal phosphorescence of the sea are the most popularly known; but most visitors to the seaside have come

across phosphorescent zoophytes, and jelly-fishes, and sea-worms, and starfishes, and all who have made a long sea-voyage have seen the brilliant coruscations of the oceanic Tunicates (*Pyrosoma* and *Salpa*), and know of the scintillations emitted by certain nocturnal fishes.

With regard to several of the luminous fishes, the actual mechanism by which the light is produced and radiated has been described, and it is also known that, in some instances, the luminous emissions are under the animal's control. Among these fishes we find every gradation of luminous organs, from a simple dazzling patch of skin, encircled by a ring of absorbent black pigment, to prevent diffusion, up to an elaborate glandular structure, provided with reflecting and condensing apparatus, very much like a bull's-eye lantern.

Our knowledge, however, of the sources of the light emitted by the higher Crustacea is still very incomplete. On the occasion of which I am now writing three large species of luminous deep-sea crustaceans were brought on board alive, namely, *Heterocarpus alphonsi*, *Aristæus coruscans*, and *Pentacheles phosphorus*. Far the most brilliant of them was *Heterocarpus alphonsi*, both sexes of which poured out, apparently from the orifices of the "green glands" at the base of the antennæ, copious clouds of a ghostly blue light of sufficient intensity to illuminate a bucket of seawater so that all its contents were visible in the

ANOTHER BENGAL-BAY LIGHT.

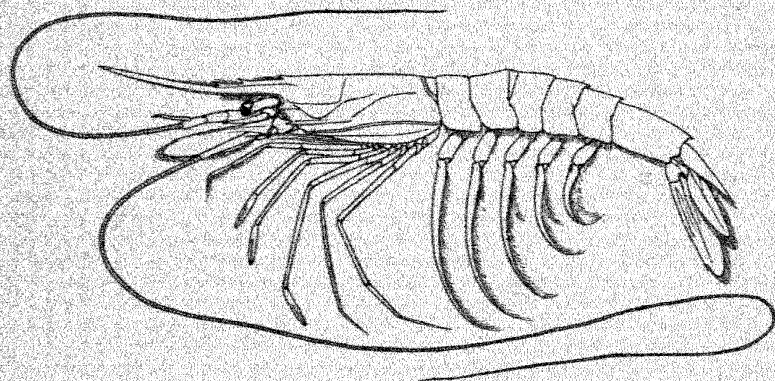

FIG. 16—*Aristæus coruscans*, a brilliantly-luminous deep-sea prawn from the Bay of Bengal, 561 fathoms. The luminous fluid is emitted from the base of the second pair of antennæ.

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clearest detail. *Aristæus coruscans*, of which only one specimen, a female, was obtained, also emitted from the same place similar clouds of light, which, however, were less abundant and less brilliant than those of *Heterocarpus*. The green glands correspond in function with kidneys, so that if, as seems to be the case, the excreta of these two prawns are luminous, the fact is by no means an isolated one. The light displayed by the female of *Pentacheles phosphorus* was a steady glow at two points near the openings of the oviducts, where there was found to be a greasy, glandular patch, very much like that seen in the same place in the females of several species of Indian prawns of the genus *Peneus*.

In this haul we also obtained specimens of a curious jet-black deep-sea fish belonging to a family (*Ophidiidæ*) related to the cod-fishes, the scales of whose "lateral line," or "slime-canal," are greatly enlarged and modified to produce light. The scales in question are all embedded in a continuous sheath of particularly black skin, which, however, is loop-holed opposite every scale, to expose a spindle-shaped cavity, filled with a greasy, opaque-white secretion, dug in the scale itself. The secretion probably oxidises slowly—the oxygen in all probability coming, not from that dissolved in the seawater, but from that contained in the blood itself—so as to produce a cold phosphorescent light. When all its lamps are shining, the fish must have

somewhat the appearance of a lilliputian ship seen by night, with a row of port-holes along either side lit up. In allusion to this row of lights, we called it *Lamprogrammus*, or "line of radiance."

We reached the Coco Islands on the 8th November, and stayed there two days to cut in some points and land a boat-party, and then we went on to Port Blair for news of the world. The sea off Little Coco was swarming with sharks: so many were there, that all the big sea-perches that we caught on our fishing-lines were bitten short off at the head before we could haul them in. As we ran down the east coast of the Andamans, we dredged twice, in 683 and 922 fathoms, on a bottom of rather foul blue mud of a temperature of 42°.9 and 41°.2 Fahr., and got a few fishes, crustaceans, mollusks, echinoderms, worms, and sponges. Among them were a fish, *Bathygadus longifilis*, and a starfish, *Porcellanaster cæruleus*, which are also found in the North Atlantic. At the 922-fathom station we also obtained a gigantic crab-spider (*Colossendeis gigas*), the span of whose lanky legs was nearly 20 inches: the creature, as it lay on its back, shone like a star, all its legs being lit along their ventral surface with a strange greenish-blue radiance. What use this bright light can be to a perfectly blind animal, that appears to feed, like an earthworm, on mud, it is difficult to conjecture, unless, as Sir John Murray suggests, it is useful to scare enemies.

AN INDIAN FIRE-FISH.

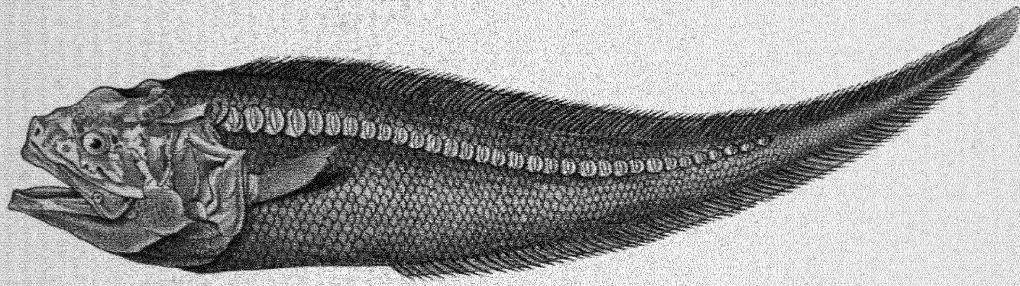

FIG. 17.—*Lamprogrammus niger*, a luminous deep-sea fish from the Bay of Bengal and Andaman Sea, 405-561 fathoms. The luminous organs are lodged in the row of large scales of the lateral line. Half the natural size.

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The sea at the 683-fathom station was full of little balls of beautiful blue fire, which in the still undissipated gloom of early dawn shone like stars. We took some up with the tow-net, and found them to be the well-known *Thalassicolla*.

On returning to the Coco Islands from Port Blair, where we had been joined by Dr Prain, of the Calcutta Botanic Gardens, Dr Prain and I were once more marooned on Great Coco, this time at the southern end of the island. We pitched our tent in open ground under some coconut palms, among the sprouting nuts of a new generation, and as before, we had to assist us in our explorations a venerable native botanical collector of scholastic appearance, two lascars in blue, and a jolly-boat. Here for nine happy days we lived serene, breathing the clean, salt air of our own unrivalled domain, wresting their unfailing treasures from the reef and jungle, and filling up the storehouse of experience with facts and fancies for future use and delight. But my fair records are blotted by the memory of one black crime; for I lay in ambush for the blameless wild cattle of that island paradise, and in cold blood I slew an innocent young bull for the sake of beef. I can only plead that there were five men to feed; nor did anyone lack of the equal feast.

I have already said something of the natural history of Great Coco Island. Here, at the southern

end of the island, we noticed how the coral shore between tide-marks was being consolidated by species of *Madrepora*, *Porites*, and *Pocillopora*, all of which were growing luxuriantly (though their colour was pale) notwithstanding the fact that they were left dry at the ebb-tide, and exposed for hours at a time to the fierce rays of the sun. We saw great flat-topped slabs of *Porites*, as much as 15 feet in diameter, dead on top but in vigorous growth at the circumference, some of them already nearly filling up, and promising to ultimately obliterate, the tidal pools in which they began their existence.

Off the southern point of Great Coco is the little islet of Jerry, which, indeed, is only separated from its big sister at high water. Much coral shingle is, however, accumulating in the channel between the islands, and at one spot has even been thrown up a foot or two above the flood, so as to form a low bank, upon which, at the time of our visit, a miscellaneous flotsam and jetsam of coconuts, big leguminous seeds, and other woody fruits had already found a promising resting-place. This little eyot, now in the throes of birth, may one day fill the channel between the two islands, though a heavy storm may at any time wash it clean away.

Grey mullets swarm in the pools left by the tide; but they are by no means easy to catch, for they seem to know the country, and when hemmed in they

think nothing of taking a flying leap across the dry rocks into another chain of pools. The shallower pools are often filled with writhing masses of brittle-stars, but it is difficult to get a perfect specimen, owing to their habit of threading their long snaky arms through and through the crannies of the rocks. In a single morning one might see hundreds of specimens of one species (*Ophiothrix longipeda*), and this gives one an impressive lesson as to the manner in which coral-reefs are augmented and solidified, by the death and burial of the shoals of calcareous animals that are generated upon them.

There are in Great Coco, connected with some of the mangrove swamps, some little creeks, which get filled now and again at high spring-tide, and become dry, or nearly dry, in the intervals between the spring-tides. In one of these, which still contained a little very foul seawater, I found a multitude of small species of sea-perches (*Pristipoma*, *Therapon*, and *Dules*), most of which were dead and decomposing, the few survivors being almost at the last gasp. This observation throws some light on two important kinds of natural phenomena, namely, modes of origin of fossils, and modes in which freshwater faunas are initiated and recruited from the sea. Here, in fact, was seen, *inland*, the early foundations of a bed of marine fossils; and all we have to do, in order to complete the story, is to imagine the heap of victims being augmented at each successive

period of spring-tides, until at last the creek is filled up with their remains, mingled with fallen leaves, etc., from the overhanging jungle. If, on the other hand, the creek should have become connected with a channel of rain water—as does sometimes occur on the Cocos—then some of the marine animals periodically thrown into it by the spring-tides may live, even should the periodic communication with the sea altogether cease, and may, if the fresh water be of sufficient extent and volume, gradually colonise it, and flourish in it even after the parent stock has become extinct in the sea.

Among the animals that we noticed in the jungle, there were, in addition to those observed the year before, a land-crab (*Geograpsus grayi*) which we had encountered in the Laccadives, an Agamoid lizard (*Gonyocephalus subcristatus*), peculiar to the Andaman-Nicobar chain, and a beautiful little tree-gecko (*Phelsuma andamanense*), found only in the Andaman group. This little gecko is one of the most brilliant lizards in existence: above, it is of the most vivid emerald-green, flecked here and there with orange-red; below, it fades to yellow, the throat being of a particularly bright hue.* Peculiar interest attaches to this little denizen of the jungles, because its known congeners are confined to Madagascar and the neighbouring

* Like most lizards, *Phelsuma andamanense* can change its colour on occasion; for instance, on a dark background, or in bad light, it turns a dingy brown, and its orange markings become dim and obscure.

islands—Comoros, Mauritius, and Seychelles—of that region.

After striking our camp on Great Coco, we spent nearly a week in exploring the island of Little Coco, which lies about 9 miles to the south-east, the channel between the two islands being full of dangers. This island, which runs nearly due north and south, is hardly 2½ miles long, and between half and quarter of a mile broad. If you keep to the beach, which consists chiefly of dead coral, in places rising abruptly out of deep water, you can stroll round it in a morning; but if you wish to cross it, you find that after passing through a fringing belt of coconut palms, carpeted with convolvulus (*Ipomœa biloba*), you have to cut your way, first through thickets of screw-pine, and then through a dense jungle with a matted undergrowth of thorny canes and creepers, before you reach the open forest that clothes the narrow central ridge. In the jungle, the little long-snouted and short-tailed Andaman pig (*Sus andamanensis*) will be seen, the fallen fruits of cycads and of the "country almond" (*Terminalia*) furnishing it with abundance of food. We also came across spiders—a gaudy *Gasteracantha*, hanging exposed in an obtrusive web; and a curious, long-legged species, which, as it hung from a single thread, exactly resembled a dead leaf in colour and form. But, as on all these islands, the principal inhabitants are land-crabs of various kinds.

On the beach there were numerous tracks of turtles, whose *caches* of eggs we several times found violated by the great water-lizard (*Varanus salvator*). From the stomach of one of these voracious lizards shot by Lieut. Kendall, we turned out two large reef-eels, a full-grown land-crab of the largest kind, and a mass of roots.

At the southern end of the island is a lakelet, several acres in extent, and from 6 inches to 2 feet deep, of water which, if not perfectly fresh, is at any rate so very slightly brackish as to be quite fit to drink. Though surrounded by healthy mangroves, its own flora consists of such characteristic freshwater plants as rushes, lotus, and the cosmopolitan pond-weed *Chara*. What its fauna may be I much regret to be unable to say, for though we shot some of the Andaman teal that had made it their home, we failed to catch any of the fish that we saw rising in abundance. This sheet of practically fresh water is undoubtedly one of those mangrove creeks, already alluded to, which has become cut off from the sea, and then converted into a lake by the accumulated surface drainage of this rainy island. The waveworn sandstone rocks that stud its surface, and the blocks of unaltered coral and the marine shells scattered along its shore, show how recently it must have been an arm of the sea, though it is now separated from the beach by a thicket about twenty paces in width.

Comparing Little Coco with Great Coco, what strikes one most on the former island are the fringing, cliff-like coral-reefs which so often rise sheer out of water 10 fathoms deep, and the presence of numerous pigs and large water-lizards. These two animals I never saw on Great Coco, and I am inclined to think that they have been exterminated there by the descendants of the pariah dogs which were left behind by the people who once attempted to colonise the island. In a former chapter I mentioned how, in our camp at the northern end of the island, we made the acquaintance of an ancient specimen, whose demeanour showed that she was familiar with man. This year, at the southern end of the island, we encountered what we took to be her descendants, who slunk away silently like jackals, and had lost all right to the specific epithet *familiaris*.

When November was past, Captain Hoskyn thought that the weather on the Coromandel coast would be settled enough for survey work, so on the 9th of December we left Port Blair, and I took my final farewell of the enchanting islands of Andaman.

Should the Cocos remained unreclaimed, and should they at some distant time be visited by a naturalist, there are three interesting biological inquiries to which that naturalist of the future might direct his attention. The first is, as to the modifications undergone by the Indian cattle, which have

been turned loose there, and have already become feral. There is on the island a sufficiency of coarse grass, bamboo, and fresh water for the support of a small herd of them. What will these cattle become like?

The next relates to the domestic (pariah) dogs which have become wild there. For them there is plenty of miscellaneous feeding on the reefs and in the jungle, and so they should not die out. But what modifications will they undergo?

The third inquiry is connected with the fauna of the freshwater lake on Little Coco. There is abundant evidence that this lake was, not very long ago, a mangrove creek in open connection with the sea, and there is no evidence that man had anything whatever to do with its conversion. There is no other fresh water on the islet, so that here we seem to have a perfectly clear sheet upon which to record the manner of colonisation of a freshwater territory newly won from the sea.

# CHAPTER X

## THE DARK UNFATHOMED CAVES OF OCEAN

Last Recollections of the Andaman Sea: A Miraculous Haul in 188-220 Fathoms: Glass-rope Sponges: A Hospitable Star-fish: Other Queer Fishes: The Lobster and its Deep-sea Relatives. A Haul in 405 Fathoms: Coral Relics of a Bygone Age: *Lumen ademptum.* The Submarine Plain of the Bay of Bengal and its Fauna. Hearts of Oak: *Pro cive servato.* Viviparous Bony Fishes. Viviparous Elasmobranchs.

BEFORE we left the Andaman Sea, we took two last hauls of the trawl, in 188-220 fathoms and 405 fathoms, in the neighbourhood of the Cinque Islands. The first of them was the most prolific that I have ever assisted at. Though the bottom was soft green mud—temperature 56° Fahr.—the trawl was so skilfully handled by Captain Hoskyn, that it did not fill with that objectionable and disappointing substance, but brought up such an enormous load of specimens, that I despaired of getting them safely laid in their first pickle of spirit before they should go bad.

As the trawl-bag came clear of the sea, it seemed at first sight as if it had fouled a sunken haystack, for there stuck out on all sides things that looked

like long bundles of hay, with here and there a bird's nest attached, which on closer inspection turned out to be great Hexactinellid sponges. Professor F. E. Schulze, of Berlin, has described and figured the long ones as *Semperella cucumis*, and the bird's nest forms as *Pheronema raphanus*. These Hexactinellid sponges, of which the Venus' flower-basket and the glass-rope sponge are familiar examples, are at the present day found only in the deep sea, where, however, they are abundant. They usually anchor themselves in the soft bottom by long threads or spicules of opaline silica, which sometimes are grouped into loose bundles like tufts of fine spun-glass, but at other times are twisted into stout strands or "glass-ropes." In both *Semperella* and *Pheronema* the roots or anchoring-tufts are of the first kind.

In the trawl there were sea-pens of the genera *Pennatula* and *Umbellula*, hundreds of specimens of the curious sea-urchin *Phormosoma*, that looks like a Tam o' Shanter cap, numerous jelly-like Holothurians, and several species of starfishes, one of which (*Dictyaster xenophilus*, or "befriender of guests") gives a lodging to, and even provides accommodation for the eggs of a sea-worm lodger. Besides these there were two kinds of cuttle-fishes, and a singularly large and elegant bivalve mollusk of the genus *Verticordia*. All these, however, formed but a small part of the haul, the bulk of which consisted of fishes and

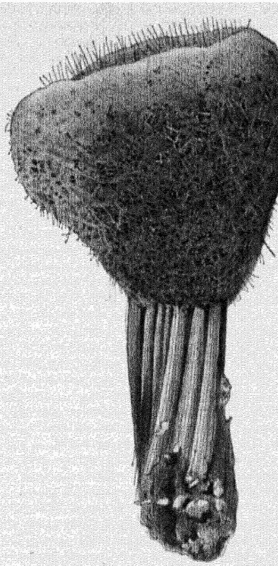

FIG. 18.—*Pheronema raphanus*, the Indian Bird's-nest Sponge; from the Andaman Sea, 173-405 fathoms; reduced.

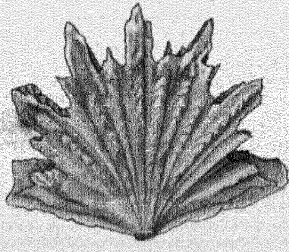

FIG. 19.—*Flabellum laciniatum*, the deep-sea fan-coral, found in all parts of the Indian Seas at 400-600 fathoms. The same species has been dredged in the depth of the North Atlantic, and occurs as a fossil in the Tertiary rocks of Southern Europe.

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crustaceans. Of these two classes of animals there were many hundreds of specimens, representing twenty-three different species of fishes, and twenty-nine different species of Crustacea. Among the former there were no less than four distinct kinds of frog-fishes, those grotesque monsters, of which the sea-devil or fishing-frog (*Lophius piscatorius*) of European seas is the type, who lie in wait at the bottom of the sea with their enormous trap-like mouths agape, while they lure their prey, after the manner of anglers, by the play of one of their dorsal fin-rays, the tip of which is modified to resemble a bait.

Among the crustaceans there were many specimens of *Nephrops thomsoni*, a true lobster, very little different from the spiny lobster (*Nephrops norwegica*) of the North Atlantic; some of them were females with eggs attached, the eggs containing embryos whose growth was sufficiently far advanced to show that in this species, as in several other members of the lobster family, the newly-hatched young resembles the parent in possessing the full number of appendages. Though *Nephrops thomsoni* itself is of a pink colour, its embryos, as seen in the egg, are dark blue. Among other acquisitions worthy of special notice, there were some fine specimens of a primitive kind of crab (*Homola megalops*), belonging to a genus which, for many years, was supposed to be confined to the Mediterranean Sea and North Atlantic, but which we now know to be

represented in the deep seas of India by three distinct species, besides the species (*Homola orientalis*) discovered off the Philippines by the *Challenger*. This *Homola megalops* is, like *Nephrops thomsoni*, remarkable for the large size and intensely black colour of the eyes, from which we may infer that at a depth of about 200 fathoms there is still some light for animals whose eyes are big enough and powerful enough to catch it. With these two visually well-endowed crustaceans we dredged a number of specimens of the blind lobster (*Nephropsis stewarti*), whose eyes are colourless rudiments, although the eyestalks are present. Both *Nephrops* and *Nephropsis* are as closely as possible related to the ordinary edible lobster (*Homarus vulgaris*), all three forms being probably descended from a common ancestor which possessed eyes of ordinary size attached to movable eyestalks. Of the descendants of this ancestral form some would have retained eyes of average size and strength, and these would have remained in comparatively shallow and well-illuminated water, and would have given rise to the common lobster of the fish-market (*Homarus*). But others, urged by that unrelenting competition which is felt throughout the whole of organic Nature, would have emigrated to the depths, that to ordinary lobsters are Cimmerian darkness; and of these emigrants some—since inequality of endowment is one of the inevitable facts of existence—would have had

FIG. 20.—*Prionocrangon ommatosteres*, a blind deep-sea Shrimp from the Andaman Sea, 405 fathoms. The eyes are completely atrophied, and the eyestalks are reduced to mere scales. The basal joint of the antennules, which contains the organ of hearing, is very greatly enlarged, perhaps to compensate for the loss of vision.

good eyes and some bad. Those with good eyes would gradually have been able to make themselves at home in the moderate depths (100 to 200 fathoms) which are faintly lit by some struggling gleams of light, and they, by a gradual and natural weeding out of all the optically-unfit individuals, would, in the course of generations, have been transformed into a race like *Nephrops*, which is characterised by eyes of extraordinary power. At the other extreme, those with bad eyes could quite naturally have adapted themselves to those pitchy abysses, where eyes are not only useless, but, being sensitive and peculiarly vulnerable structures, are a source of danger, and there, by the continuous elimination, through many generations, of such unfit individuals as still retained these effete organs, would at last evolve into a form like *Nephropsis*, whose eyes are gone, but whose eyestalks remain, like, as has been aptly remarked, armorial bearings that give evidence of a nobler descent.

Before I leave speaking of this prolific trawling-ground, I must mention that, several years afterwards, my successor in the *Investigator*, Dr A. R. Anderson, again had the trawl shot on this very spot, in the hope of repeating this miraculous draught; but on the second occasion, although no mistake or accident is known to have occurred, almost nothing was taken —a result as unexpected as inexplicable.

Our trawling in 405 fathoms, though not equal to the first, was still very productive. The bottom was the same green mud, but the temperature had fallen to 47° Fahr. There were Hexactinellid sponges, dozens of specimens of *Phormosoma*, and a fine specimen of a coral (*Flabellum laciniatum*), which until then had been known only from the North Atlantic, and as a fossil from the Tertiary rocks of southern Europe. There were many rarities among the Crustacea of this haul, one of the more remarkable being a blind shrimp (*Prionocrangon ommatosteres*), in which the eyes are completely aborted, and the eyestalks reduced to scales; but perhaps in compensation for its blindness, the basal joint of its first pair of antennæ, in which the organ of hearing is enclosed, is of singularly large size. *Psalidopus spiniventris* is another very strange shrimp which was taken at this haul. This creature is covered like a porcupine with long and sharp spines, but the most peculiar parts of it are the first and second pairs of legs; the first pair end, not in mere pincers like those of ordinary crabs and lobsters, in which one blade is fixed, but in scissors of which both blades are movable and work across one another; the second pair end in a brush, like a camel's-hair pencil, instead of in an ordinary claw. It is impossible to say what the peculiar conditions of life are that have led to this peculiar modification of the legs of *Psalidopus*. The brushes of the second pair of legs may, perhaps, be

THE SCISSOR-FOOT PRAWN.

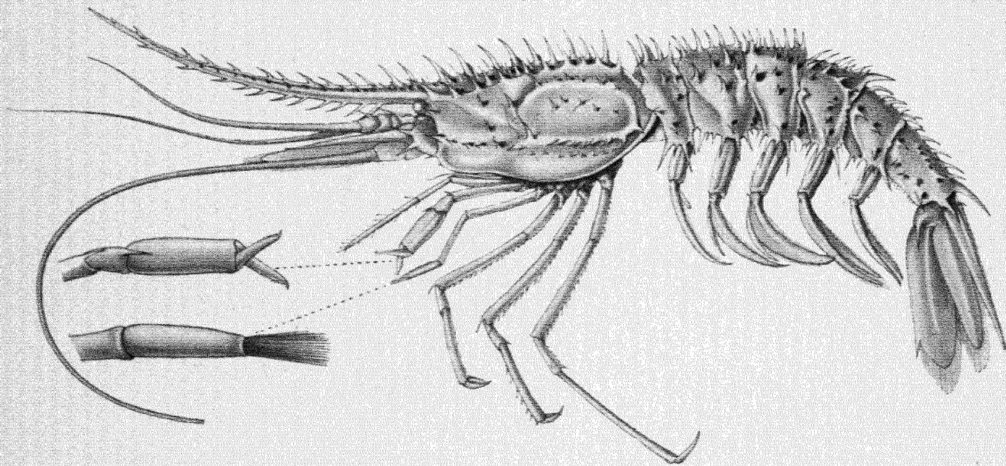

FIG. 21.—*Psalidopus spiniventris*, the blind Scissor-foot Prawn of the depths of the Andaman Sea. The chelæ are unique, in being formed like shears, and the second pair of legs end in a brush of hairs. The shears and the brush are shown, enlarged, on the left.

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organs of touch, since the eyes of *Psalidopus* are very small, and are quite devoid of facets and pigment, and so can be of no use for distinct vision, even if they are sufficient for the discrimination of light from darkness.

A third noteworthy crustacean dredged upon this occasion was a hermit-crab (*Parapylocheles scorpio*), in which the body is as symmetrical as that of a lobster. In most hermit-crabs the abdomen or "tail" is soft, and has a spiral twist, and the abdominal legs are present on one side only; but in *Parapylocheles* (as in the rare genera *Pylocheles*, *Pomatocheles*, *Mixtopagurus*, *Xylopagurus*, and *Glaucothoe*) the abdomen is perfectly straight, and is soft only on its under surface, and has the proper number of legs on both sides. All these forms are, in fact, connecting links between the lobsters and the typical hermit-crabs, and are specially interesting on that account. In *Parapylocheles scorpio* the eyes, though somewhat pallid and extremely small, are properly formed, and are probably of some slight service to the animal.

After heaving-in the trawl, we passed through Manners Strait into the Bay of Bengal, and I then had the mortification of passing South Sentinel Island —the only Indian home, unless the Nicobars be included in India, of the robber land-crab (*Birgus latro*)—without being able to land there. I was particularly anxious to spend a few hours on the island in

order to search for brooding females of *Birgus*, for I had reason to believe that females in this interesting condition might possibly be found there in the month of December, and in those days we did not know, and were exceedingly curious to discover, what the newly-hatched young of the robber-crab was like—whether it was from the moment of its birth adapted for life on dry land like its parents, or whether, like its more remote ancestors, it passed through any water-breathing larval stages before betaking itself to a shore-going life. We unfortunately missed the opportunity of contributing anything to the solution of this exciting question; but that accomplished and successful naturalist, Dr Arthur Willey, has since discovered, when working among the Loyalty Islands, that the female robber-crab hatches its eggs into the sea, and that the young leaves the egg as a *zoæa*, adapted for an aquatic life, like the larvæ of ordinary marine hermit-crabs.

We crossed the Bay to Madras, between the twelfth and thirteenth parallels of latitude, sounding eleven times and dredging three times in deep water on the passage. We found that between the parallels mentioned (12° and 13° N.) and the meridians of 90° and 82° E., the depth of the sea does not vary more than 100 fathoms. In this region, in fact, the floor of the Bay of Bengal is a level plain of chalky paste (Globigerina-ooze) lying a little more than 10,500 feet

below the sea-level, sloping almost imperceptibly towards the south-west, and having a temperature all the year round of 35° Fahr. Scattered here and there our dredge finds waterworn pebbles of pumice-stone, which have sunk after having in all probability been carried thousands of miles by ocean currents before they became water-logged and fell to rest.

Pitch-dark and freezing cold as this part of the submarine plain is, we discovered nearly fifty species of animals which must actually live upon it, not including some free-swimming species that flit in the canopy of water above it, and probably pay it only occasional visits. If we inquire into the inter-relations of these fifty species we shall discover a striking illustration of the fact that, given a tract where the conditions are uniform, then if life greatly flourishes upon it, it must be diversified life; for these fifty species, all practically living on one plot of land, belong to thirty-six different genera, twenty-four different families, eight different classes, and five distinct phyla or "subkingdoms." Growing on its surface, like plants on a heath, there are several kinds of Hexactinellida (*Hyalonema*, *Holascus*, *Saccocalyx*, *Bathydorus*), those beautiful glass-sponges already spoken of as characteristic of the deep sea; and encrusting the roots of some of these, barnacles of two kinds were found. Starfishes, sea-cucumbers, and sea-urchins of over thirty different kinds creep over these oozy pastures, many of them

gorging themselves with the ooze—as earthworms do with garden mold—for the sake of the particles of organic matter that may be mixed with it. Among the starfishes we find several members of the characteristic deep-sea families to which *Porcellanaster*, *Hymenaster*, and *Freyella* belong. Of these *Hymenaster* is of peculiar interest, because it carries its eggs in a hollow of the back, which hollow is roofed over by a sort of secondary skin so as to form a covered brood-chamber: a hole in the roof, which can be closed at will, gives exit to the young. Conspicuous among the sea-cucumbers are the species of *Deima*, curious forms with a strong resemblance to large sea-slugs, and differing from Holothurians of all other families in having the body encased in a firm calcareous shell something like, though not so strong and thick as, that of a sea-urchin.

Several species of crustaceans, most of which are either blind or have small or defective eyes, crawl or flit over the ooze. The commonest of them seems to be a hermit-crab (*Parapagurus pilosimanus*), whose habit of living in a house of sea-anemones has already been referred to: the eyes of this creature though small, are quite perfect in form and colour, and since there can be no doubt that the animal actually lives upon the bottom at depths to which no sunlight can possibly penetrate, we are almost led to infer that the light by which it sees must emanate from the sea-

anemones with which it is commensal. The other crustaceans who live in company with this *Parapagurus* (but without any sea-anemone messmates) must be almost or quite blind, since their eyes have become dull and opaque, and have lost nearly all their colour; such are *Glyphocrangon cæcescens*, *Pontophilus abyssi*, and the species of *Munidopsis*. In *Willemœsia forceps*, a sort of fragile lobster, which also lives in this abyssal locality, the degradation of the eyes has gone even further, for they have become completely colourless, while the eyestalks are immovably affixed to the carapace. Two species of prawns (*Dorodotes reflexus* and *Acanthephyra microps*), complete the list of crustaceans which we have dredged on our abyssal plain: their eyes, though small, and though a little paler than those of their congeners, are still well-formed and serviceable, but there is considerable doubt as to whether these species really live on the bottom, or ascend and descend in the gloomy canopy above. The same doubt applies to the two fishes of the Ophidioid genera *Neobythites* and *Dermatorus*, which we twice found in the trawl when dredging at a depth of nearly 1750 fathoms. But the blind mollusk which we brought up from 1803 fathoms must have come from the bottom, seeing that it is a bivalve closely related to the scallops of shallow water: it has been named *Amussium solitarium* by Mr Edgar Smith.

One of our three hauls on this passage across

the Bay came very near to ending in a tragedy, in this wise. As we lay-to to sound before trawling, three large sharks came up and lazily inspected the ship. Our ideas on seeing them being reciprocal of theirs on seeing us, we called for hooks and salt pork, and soon had our shark-lines shot overboard. In due time, when the trawl was safely dragging on the bottom, we went to breakfast, leaving the officer of the watch, Lieutenant W. B. Huddleston, on the forecastle in charge of the dredging operations, while Gunner Peterson kept an eye on the shark-lines from the same place. We had not finished breakfast when the noise of a tumult, such as sounded very strangely on one of Her Majesty's ships, reached the ward-room and sent us hurrying forward, where we found the gunner being wrung dry by lascars and the dripping figure of Mr Huddleston clambering over the ship's side; and I on looking over, saw Mr Huddleston's cap floating on the water, with a large shark rising at it—a sight that I shall never forget.

We then learned that, after we had gone to breakfast, one of the sharks had taken our bait, and that as it resisted all efforts to haul it in, the gunner had sent for a rifle to shoot it withal. But in his anxiety to get as close a shot as possible, he fell overboard, and of course, like the majority of European fishermen and sailors who have not had a naval training, he could not swim. Without a thought about the other

two sharks who were shadowing the ship, without wasting time even to wrench off his coat or kick off his shoes, Lieutenant Huddleston was overboard after him: the lascars were equally ready with lines, and before we who were aft knew anything about the accident, the gunner was rescued and Mr Huddleston was half-way up the ship's side again, but only just in time.

For this noble and fearless deed Lieutenant Huddleston was awarded a silver medal by the Royal Humane Society, and was subsequently adjudged the Stanhope gold medal for the most gallant act in the annals of the sea for the year 1890.

I may mention that the shark which had been the cause of all this trouble was shot, and made lawful prize, but that its two companions—one of which had been in such dangerous proximity to Mr Huddleston—cleared off.

After taking in coal at Madras we steamed up coast to Bimlipatam, where surveying was to begin. When off the Kistna Delta, we dredged in 240-276 fathoms, and found a bottom of brown mud, the temperature being 52° Fahr., or twenty-eight degrees less than that of the surface water. Here we got a trawl-bag full of fishes and crustaceans of many different species. Among the fishes was a specimen of a little Ophidioid, *Saccogaster maculata*, the female of which does not lay eggs but brings forth living

young: in each ovary only the eggs of the layer that lies immediately beneath the ovarian envelopes give rise to embryos, and it seems as if all the rest of the roe were used up as food by the unborn fry. There is nothing improbable in this suggestion, for it is well known that in the *Embiotocidæ*, a small family of viviparous bony fishes that inhabit the coasts of the North Pacific, the developing young are in part nourished by the epithelium of the wall of the mother's ovary.

The Crustacea of this haul included a number of specimens of a new kind of prawn, *Psathyrocaris fragilis*, remarkable for the enormous length of the exopodites of the last four pairs of thoracic, and first five pairs of abdominal legs: so long are these exopodites that the creature at first sight looks more like an Opossum-shrimp than a prawn.

I left the *Investigator* at Bimlipatam, in order that I might myself take to the Museum at Calcutta the many boxes of specimens collected at the Coco Islands, and in our phenomenally successful deep-sea dredgings on the passage there and back. I felt as if I were unfaithful to my ship in leaving her in the middle of a surveying season; but at that time so little progress had been made in arranging and interpreting her collections that I began to think that I should serve her best by making an effort to work up some of her arrears rather than by making

any further additions to her dead weight of raw material.

On my return to the ship, two months later, I got Captain Hoskyn to maroon me on the shifting spit of sand that forms the eastern boundary of Cocanada Bay, in order that I might collect sharks and rays from the fishermen who at that time used to resort to the spit daily to drag their seines. On this forlorn spot, amid an unbroken waste of muddy waters, where the only sounds that meet the ear, when the fishermen have borne their spoil away, are the everlasting thunder of the surf, and the perpetual screaming of myriads of gulls, I was able to collect a great deal of the stuff I was looking for, as well as to make some further observations as to the manner in which, in certain viviparous sting-rays, the young are nourished before birth. I found that in the bat-ray (*Pteroplatæa micrura*) and in the small sting-ray (*Trygon walga*) the unborn and developing young ones lie loose and perfectly naked in their mother's womb, where, by means of their spiracles, they imbibe a creamy albuminous fluid, which is secreted by a vast number of small glands temporarily developed in the shaggy lining-membrane of the womb, the series of events being exactly similiar to those described in a previous chapter as occurring in the large sting-ray (*Trygon bleekeri*), and in the eagle-ray (*Myliobatis nieuhofii*). On this occasion, too, I also got a specimen

of this eagle-ray, heavy with young, and copiously secreting a rich yellow fluid that smelt, not like fish, but like beef.

This was my last opportunity of field-work before the advent of the south-west monsoon and the recess. This third recess I passed as usual at Calcutta, where, on account of the local requirements of the Service, I was ordered to act as Pathologist and Resident Physician at the Medical College, so that only my leisure time was available for natural history studies. However, Professor Wood-Mason and I were able to do some justice to the *Investigator* collections, and the results of our labours were published in a series of papers in the *Annals and Magazine of Natural History* for 1891, and in the fiftieth volume of the *Proceedings of the Royal Society*. During this recess I was able, thanks to the kindness of Rear-Admiral Sir John Hext, R.N., to make arrangements for the publication of a set of twelve plates of figures of some of our newly-discovered species of fishes and Crustacea: this was the beginning of the annual *Illustrations of the Zoology of the "Investigator,"* of which nine parts have already been issued, and many more will, I hope, be forthcoming in the future.

This recess was a very sad one for the Survey, owing to the sudden death of one of its most popular officers, Lieutenant G. L. Mathias. In him were united, in a remarkable degree, the frank and sunny

optimism of the sailor and the mild and mellow cynicism of the ripe philosopher. For eight years his infinite jest and most excellent fancy had helped to give a particularly cheery tone to the *Investigator's* company, and every one of his shipmates long and sincerely mourned for him.

# CHAPTER XI

## A TWO MONTHS' CRUISE IN THE LACCADIVE SEA

Ruins of a Stronghold of Mahratta Pirates. The Fauna of the Depths of the Laccadive Sea. Illustrations of the Philosophy of Thales. Cherbaniani Atoll. Byramgore Atoll and Chitlac Island. Dredging off Calicut. Kiltán Island: Life Assurance among Sea-urchins. Cardamum Island: The Feints of Crabs: A very rough Bed of Pumice-stone.

IN the second week of October 1891, having been relieved of my duties as Professor of Pathology and Resident Physician at the Calcutta Medical College, I rejoined the *Investigator* for my fourth and last voyage, and on the evening of the 17th the ship left Bombay to carry out her eleventh annual programme. Captain R. F. Hoskyn, R.N., was in command, with Lieutenants C. V. Smith, R.N., and W. G. Beauchamp, F. Dobson, and C. G. Sinclair, R.I.M., as assistants; and we also carried with us a boat-party, consisting of Lieutenants G. S. Gunn, R.N., and W. B. Huddleston, R.I.M., and a native surveyor.

We dropped the boat-party at Deoghur, or Deogad, a picturesque little port about 180 miles south of Bombay. This Deoghur was at one time one of the

headquarters of Mahratta piracy, and for such nefarious practices it is most villainously adapted; for, being a land-locked harbour opening on to a rocky coast by an almost hidden passage, impassable at low-water to any but light craft, it affords at once an ideal ambush and an ideal retreat. On the southern side of the harbour, overlooking the sea and commanding the entrance, is a fort, said to have been built at the beginning of the eighteenth century by pirates of the Mahratta clan of Angrias. Though now a ruin, its broad ramparts of hewn laterite are still in good enough preservation to give some idea of its former strength, and to make one wonder what sort of answer Melpomene would give if certain thrilling questions of its past history could be put to her; for in bygone days many a portly argosy of Europe vailed her high-top to the Angrias pirates, and the fate of many a white captive must have been decided in their inhospitable forts. Walking back to the harbour, I slew a deadly little carpet-viper (*Echis carinatus*), over whose body I preached a warning sermon to the boat-party who were having their camp pitched close by.

From Deoghur we went, south-west by south, into the Laccadive Sea, where we cruised for nearly two months, sketching and checking the position of the islands, running lines of deep-sea soundings, and occasionally taking a turn with the deep-sea dredge.

During this happy period, in addition to the usual out-turn of ordinary surveying work, eight successful hauls were made in depths of 700 to 1200 fathoms and one in 45 fathoms, about sixty specimens of deep-sea deposit were brought up and roughly analysed, and cursory zoological and botanical explorations were made of numerous reefs and atolls.

But before I give any account of my zoological observations on land, I must explain that they were the result of a series of short and hurried visits made, often late in the day, in company with survey-officers, whose primary duties were to take sights of the stars or to sketch in a bit of coast-line. In such circumstances it was quite impossible to form any opinion of the structure of the reefs visited: this can only be done by making large collections of growing corals, which demands exact local knowledge, very fine weather, and opportune tides—conditions, in short, that can only be secured by residence. With this limitation of my subject, I may now speak first of the Laccadive Sea, and then of its islands.

We have been accustomed to give the name Laccadive Sea to the narrow basin included between the Malabar coast on the one side and the peaks or plateaux that lodge the Laccadive Islands on the other. On the Malabar side, its bottom, which consists of dark mud brought down by small rivers from the Western Ghats, slopes very, very gently, the

gradient varying from 1 in 660 to 1 in 300, to a depth of 100 fathoms; but after that, at a distance of 75 to 35 miles from shore, it makes an exceedingly steep descent—the gradient being about 1 in 19—down to 1000 fathoms, the bottom still being mud derived from the land. In fact, if the water could suddenly be run out of this sea, we should find the Malabar coast fringed by a shelf of mud from 50 to 100 miles wide, and having a steep fall of more than 5000 feet. On the Laccadive side the bottom is utterly different: here from a broken and uneven bed of calcareous ooze the reefs and islands rise suddenly up, as a chain of mountain peaks rise out of an undulating plain. The calcareous ooze is made up partly by the waste of the coral-reefs themselves and partly by the shells of Foraminifera that fall from near the surface of the sea. Besides the mud and calcareous ooze already mentioned, we find in places "green sand," which largely consists of the shells of Foraminifera — or casts of them — impregnated with glauconite. As to the depth of the Laccadive Sea, the deepest sounding yet taken, a little south of lat. 10° N., is about 1500 fathoms. Its surface temperature ranges between 80° and 90° Fahr., according to the time of year; but its temperature at 1300 fathoms is only 35° Fahr., at about 1000 fathoms is only about 38° Fahr., and even at 300 fathoms is not higher than 51° Fahr., which is

about the summer temperature of the sea-surface in the neighbourhood of the Shetland and Faroe Islands.

Not to speak of the countless animals that inhabit the shores and shallows as well as the surface waters of the Laccadive Sea, we already know of nearly 250 species that dwell in its cold and dark depths below 300 fathoms, species which, for reasons already noticed, are of very diverse kinds, belonging to over 160 genera, about eighty different families, and nearly thirty different natural orders. Corals flourish with surprising vigour in its profound gulfs: at one spot, at a depth of 1000 fathoms, over two hundred specimens of *Caryophyllia ambrosia* were dredged, and at another place, in 430 fathoms, the trawl brought up nearly half a ton of *Caryophyllia*, *Desmophyllum*, *Lophohelia*, and *Solenosmilia:* altogether, thirteen different kinds of corals have been dredged in its depths between 430 and 1070 fathoms.

The starfishes are another class of animals that appear to find in the abysses of the Laccadive Sea a particularly pleasant residence: sixteen species of true starfishes have already been discovered there, and eighteen species of brittle-stars—most of them in great abundance. Crustaceans also are abundant, nearly eighty species having already been found, half of them being forms that cannot swim, and so must live actually on the bottom. Of mollusks we know of nearly forty species: the commonest of them seem to

be the blind scallops of the genus *Amussium*, and one of the strangest is *Pontiothauma mirabile*, whose shell grows to a length of 4½ inches, and looks just like that of a large whelk from the northern seas. The creature itself is without eyes, and although it is a Gastropod, has, according to Mr Edgar Smith, no radula. Lastly, in depths where there is such a plentiful supply of food, in the shape of crustaceans and mollusks, it is not surprising to find that fishes are numerous. Nearly fifty species have already been discovered, of which twenty are, so far as our present knowledge goes, peculiar to the shades of this sea.

To sum up: if we could make a Brobdingnagian picture of the basin in which this deep-sea fauna lives, we should first of all be struck by the abundance of rare corals: we should see large solitary species growing like flowers of the field, while the branching species would form thickets in whose grottoes crustaceans of many kinds would be observed lurking. In some places the bottom would be carpeted with a mosaic of starfishes of beautiful red and orange hues, in other places multitudes of the reed-like tubes of the sea-worm *Hyalinœcia* would show like fields of stubble, while in other places we should find beds of strange bivalves (*Amussium*, *Lima*, *Limopsis*) like the oyster-beds and mussel-beds of shallow water; and through the dead-still waters above, shoals of curious

fishes and prawns would be seen cautiously feeling their way.

Intrinsically attractive as this fauna of the Laccadive deeps is, it excites our interest still more when we discover that many of its most striking species are also inhabitants of the Atlantic, and in particular of that part of the Atlantic in which the West Indian Islands lie. Two of the most remarkable of the Laccadivean crustaceans, namely, the huge Isopod (*Bathynomus giganteus*) and the blind spiny-lobster (*Phoberus cæcus*), are Caribbean species, as also is the spiny hermit-crab (*Lithodes agassizii*), not one of the three being endowed with any but the most moderate powers of locomotion. Perhaps the most conspicuous, and one of the most abundant of the Laccadivean sea-urchins is a *Palæopneustes* (*P. Hemingi*), which is very doubtfully distinct from the *Palæopneustes cristatus* dredged by Agassiz off the West Indies. But if I were to name all the species that are common to the depths of the Atlantic and of the Laccadive Sea, it would be necessary to make quite a long list, including corals, echinoderms, crustaceans, and fishes.

We may now pass on to the reefs and islands of the Laccadive Sea, of which it may be said that in strict accordance with the theory of Thales of Miletus, their origin is water; for, in the first place, coral rock

A LINK BETWEEN THE EAST AND WEST INDIES.

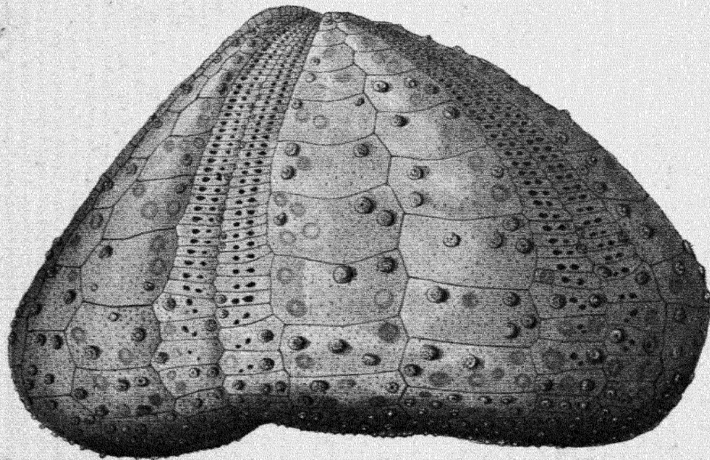

FIG. 22.—*Palæopneustes hemingi*, Anderson, a Sea-urchin discovered by Dr A. R. S. Anderson in the depths of the Laccadive Sea. It is hardly different from the *Palæopneustes cristatus* dredged by Professor Agassiz off the West Indies. The shell has been denuded of its spines, so as to lay bare its sculpture.

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secreted from seawater by sea-anemones, was piled into a low crown of dry land by the waves, and then this dry land was overspread by coconut palms, whose seeds were very likely carried by ocean currents. Again, from these coconut palms that probably owed their birth to Oceanus, a cycle of life starts and comes back by way of articulate-speaking man to coconuts again; for in such of the islands as are inhabited, the people live upon the products of the palm, and after death, being buried beneath the palms, restore to these their borrowed elements.

The first place that we visited was Cherbaniani, which from afar showed up from the universal blue as a disk of emerald, girdled by a ring of snow-white foam. The emerald disk was the lagoon, and the white ring that encircled it was the surf breaking upon the submerged atoll. Even in the finest weather, when the sea appears to be perfectly calm, the surf is one of the most impressive features of these atolls; for the gentle vertical undulations of the water, which pass unnoticed in the open ocean, break into impetuous horizontally-moving waves whenever they encounter the sudden obstruction of a reef. This surf, which only the turtles seem to enjoy, makes landing a matter of much inconvenience at all times.

Cherbaniani is a simple ring of coral-rock, which only at two small and far-distant points rises a few feet above high water, as two dazzling white eyots

of coral sand. It is one of the most desolate places that I have ever set foot on. Almost all the coral that I saw was dead; not a sign of a plant, or even of a cast-up seed or nut, was visible; and the only animals to be seen, besides a flock of small sand-pipers and an occasional bo'sun bird, were hermit-crabs of the genus *Cœnobita*, and grapsoid crabs of the genera *Grapsus* and *Ocypoda*. Even the lagoon supported but little animal life, though there were plenty of seaweeds in it, and in a whole afternoon of steady work I got nothing of any very great value; perhaps my most interesting find was two pairs of little shrimps (*Pontonia*), each consisting of a male and a brooding female, living comfortably, each pair in the mantle cavity of a giant clam (*Tridacna*). Mr A. O. Hume, who visited this atoll in February 1875, in the survey ship *Clyde*, found the noddy and the sooty tern breeding; but nothing of this sort was going on at the time of our visit at the end of October, and we did not see so much as an egg-shell.

From Cherbaniani we sounded away southwards to Byramgore atoll, which only differs from Cherbaniani in being a little larger, and in being completely covered at high tide. As it was far too rough to land on the reef when the ebb laid it bare here and there, I addicted myself not to sack but to fishing, but without success, owing to the multitude of small sharks, which appropriated everything that I hooked.

Our next line of soundings took us to Chitlac, but here again it was impossible to land on account of bad weather, so we went on to Calicut for supplies, and on the run down the Malabar coast we trawled with most satisfactory results in 45 fathoms, bringing up a deck-load of fishes and crabs and mollusks, many of which were new to science. Among the fishes there were nine specimens of the little *Minous inermis* mentioned in a former chapter, eight of which were overgrown with the commensal polyps (*Stylactis minoi*) that are never found elsewhere; for not a single polyp of this species was detected on any of the hundreds of specimens of other animals that came up in the trawl. Of the many kinds of mollusks the most attractive was a fine new species of *Murex*, which Mr Edgar Smith has named *Murex malabaricus*. We have since, however, found the same species in the Bay of Bengal.

After leaving Calicut, where we had more than our share of foul weather, and where the ship took on such abominable fits of rolling as to quite stop my work, we went to the island of Kiltán. Here we found the inhabitants in much distress and anxiety, for not only had the recent storms destroyed, so they said, 8000 of their coconut trees, but the boat which had taken a large cargo of their coir to the mainland, and was expected back with a much-needed supply of rice, was overdue, and in such

weather they feared greatly for its safety. Accidents of this kind are not uncommon in the Laccadives.

As we lay at anchor off Kiltán, I fished for coral with a grapnel, the bottom in 6 fathoms being as clear and plain as a picture, but the only piece that I brought up was dead. On breaking it open I laid bare the burrow of a small species of sea-urchin (*Echinostrephus molare*), in appearance something like the bud of a Scotch thistle, which digs into hard coral rock after the fashion of a Pholad, or of a shipworm into timber. The sea-urchin was in the bottom of its burrow, resting upon a small hoard of boiled rice, which it was eating. Of course it will be said that the rice, which no doubt had been thrown overboard from the ship, had simply fallen into the burrow during the sea-urchin's absence, but I convinced myself, by a very careful examination, that this could hardly have been the case. It is certainly difficult to give a sea-urchin credit for so much intelligence and activity as is implied by the storing up of food, but there is a good deal of evidence on record to show that among echinoderms the senses are acuter and the intelligence greater than some of us have hitherto imagined.

By the time that we landed on Kiltán the stars were shining, and although this suited the surveyors it sadly interfered with my plans.

The following morning we went on to Cardamum Island, which occupies the eastern arc of a large atoll

THE MALABAR MUREX.

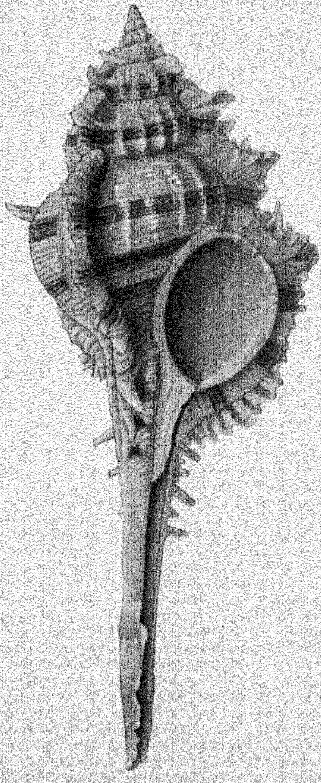

FIG. 23.—*Murex malabaricus*, dredged off the Malabar coast from a depth of 45 fathoms. This species is also found on coral ground in the neighbourhood of the Andamans, at a similar depth.

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south of Kiltán. Though it is the largest island of the whole archipelago, if Minnikoy be excluded, yet it is—or at any rate was—singular in being very little inhabited. The northern half of the island, instead of being covered with coconut trees, was a waste of coarse high grass, scrub jungle, and thickets of screw-pine, tenanted only by the inevitable hermit-crabs. As the soil is quite as good as that of any of the other islands, and as there is the usual abundant supply of fresh water a few feet below the surface, I could not account for this appearance of neglect; but Mr A. O. Hume, who explored the island in 1875, seems to think it is the result of an oppressive influence exercised by the capitalists of the adjacent small but thickly-populated island of Ameni. At the southern end of the island, sequestered in a grove of coconuts, we found a small village of very second-rate huts, built for the most part of palm-leaf matting. Here, too, there were fine lime-trees growing, and bearing fruit such as one seldom sees in India; so that I began to think that with such trees and such suitable soil, and with the markets of India so close at hand, the Cardamum Islanders were sinfully neglectful of their opportunities. However, these tranquil folk are probably the best judges of their own affairs: they are few; there are coconuts enough and fish more than enough, and the climate if not always afternoon, is always balmy; and perhaps they are vaguely aware that—especially if their power-

ful neighbours of Ameni are, as has been said, jealous and overbearing—riches only lead to trouble, and that desires gratified only beget further vain longings, and that after all light sleep beneath ancestral palm trees untroubled by fear or greed, means a pleasant if unromantic existence.

On the sandy beach of the Cardamum lagoon there were many swarms of the large grey Ocypode crab (*O. ceratophthalmus*). This crab, instead of flying swiftly to its burrow when pursued, as most of its congeners do, simply crouches close in a rudely-scooped hollow, and there lies perfectly still, looking like a stone partly embedded in the sand. Whether this curious feint is to be regarded as the starting-point of the burrowing habit of the Ocypodes, or as a convenient simplification of that habit, it is difficult to say. Judging, however, from the prevalence with which, among the higher Crustacea, species are protected by their resemblance to inanimate objects, such as bits of worm-eaten rock, etc., I should imagine that the ancestors of the Ocypodes were a stock of crabs that escaped the eyes of their enemies by crouching motionless in unlifelike attitudes, and that one branch of this stock was perpetuated by certain individuals that crouched so close as to make a "form" or hollow in the sand. This would give abundant protection to a species such as *Ocypoda ceratophthalmus*, whose colour harmonises with that of sand, but would be insufficient for conspicuously

coloured species such as *O. macrocera*. But among those descendants of the original stock that happened to be brightly coloured, some individuals would certainly —since inequality of powers and performance is one of the facts of nature—have scratched deeper holes than others; and as those which did not scratch deep would be the most likely to be seen and destroyed, we should in the course of long generations have only the very good diggers left to form an active, deep-burrowing species.

One of the most singular observations made on Cardamum Island was due to Lieuts. Smith and Sinclair, who discovered, a little inland of the northern end of the island, a bed of pumice-stone. Lieut. Sinclair was particularly and very literally impressed by it, because, going ashore to "take stars" one evening, he had to sit upon it, nor was he able either to dig down to softer ground beneath, or to find a convenient spot that was free from it. Both officers were quite sure that it was pumice, and even the lascars, who are constantly using the article, took notice of it. Unfortunately when I heard about it next morning, Cardamum Island was far astern of us. How did the pumice-stone get there, above the ordinary high-water mark on an almost uninhabited island? This, like Sir John Falstaff, I must leave—a question to be asked; for I unhesitatingly dismiss the explanation which has since been made, that two intelligent and experienced naval officers do not know what pumice is.

I still retain happy memories of Cardamum, for it is the only one of the inhabited islands that we visited where I was able to stroll about and collect without being followed by a crowd of importunate patients afflicted with hopelessly chronic and incurable diseases.

NOTE.—In a paper published in the *Journal of the Asiatic Society of Bengal*, pt. 2, for 1895, Captain C. F. Oldham, R.N., gives, in some detail, an account of the bed of pumice discovered on Cardamum Island by Lieuts. Smith and Sinclair. Captain Oldham differs from me in thinking that the phenomenon demands no special explanation.

# CHAPTER XII

## A TWO MONTHS' CRUISE IN THE LACCADIVE SEA

*(continued)*

Betrapar Atoll: Aggressive Eels. Aucutta Island: Dead Flies in the Ointment: Sea-fish in Freshwater Ponds. The Lamentable Story of Pitti Sandbank. The Island of Minnikoy: Geography and Geology: The Lady of the Land: Social and Domestic Institutions: *Ad Illacrimabilem Plutona.*

AFTER leaving Cardamum, where I collected, both of plant and animal life, as much as I could get in a single day, we went to Betrapar, an atoll which, except at one small spot at its extreme northern end, is submerged at flood-tide. On this forlorn spot of dry land, which is known as Tree Island, I landed one evening with some surveyors who were going to "take stars." As it was low spring-tide, we had to leave our boat at the outermost edge of the atoll and to wade across the reef to the island, and during this delicate progress—for growing coral is by no means pleasant stuff to walk upon, even when a man is shod—we were surprised to find ourselves furiously attacked by a swarm of the spotted reef-eel (*Muræna pseudothyrsoidea*), for it was their breeding season, a period when they are always strangely irritable and

aggressive. As I ignominiously dodged these foolish and presumptuous fish, I was able to take note of two kinds of reef-building corals—a *Porites* and a *Mæandrina*—growing strong and healthy in places that had been left dry by the fall of tide.

The island, which is a mere bank of coral sand, supports a fair amount of vegetation, besides coconuts and numerous coarse tussocks of some kind of sedge. At its northern end every tree and bush is completely overgrown and hidden under a thick pall formed by a spreading species of convolvulus which was covered with large white blossoms. Here, too, in a grove of coconuts, and surrounded by sacred *tulsi* bushes, there are a few huts, one of which, much superior to the others, has walls of coral-stone, and is said to be the shrine of a saint. There are no inhabitants on the islet, except the inevitable cenobite hermit-crabs, which are particularly numerous; but people from the other islands pay periodical visits, probably to collect coconuts, for there is nothing else to attract them unless they have time for picnics.

After taking observations for fixing the position of Betrapar, the *Investigator* ran a line of soundings to Paremulpar, which is an atoll with one little barren sandbank showing above high-water at its north-eastern end, just as at Betrapar, but drying at low-water in several other places. Unfortunately, I had no opportunity of landing on the island by daylight.

Leaving this unprofitable spot, we proceeded, making numerous deep-sea soundings, to Aucutta, a fine large populous island standing at the southern end of an atoll which also rises into small islets at two points farther north. The island is thickly covered with coconut palms, beneath which the thatched coral-stone houses of the inhabitants are picturesquely scattered among lime-bushes and pomegranates, on which fine fruit was hanging. I was surprised to notice thickets of the deadly datura growing near some of the houses, but when I asked a venerable white-bearded islander how, why, and when such a useless and noxious plant was introduced, he piously answered that he supposed it was sent by Providence along with all the other productions of the island, and declined to discuss the matter any further. Evidently the poor man was not addicted to metaphysics. If it had been the nearly-related tobacco-plant, the good old man's simple faith would have been justified; but strange to say the people of these islands are most unaccountably indifferent to the virtues of tobacco, their life, perhaps, being already quiet enough without the help of any artificial sedatives. But, indeed, one might speculate profusely if not profoundly on these matters, for there are people in the world who would have been more shocked at seeing tobacco than at seeing datura growing on an island so fair.

The chief industry of Aucutta is, of course, the manufacture of coir for export, but a good deal of boat-building goes on, for the men are skilful fishermen and sailors. But of all these things I shall tell hereafter, when I come to speak about the island of Minnikoy, where I had time to see, and ask, and learn for myself.

Among the sights worth seeing at Aucutta are the public baths. One would naturally expect that on an island not a square mile in extent, with a large, safe, and beautiful lagoon specially adapted for bathers on its lee, the people would bathe in the lagoon, and would keep all their dry land for coconut plantations, or even for the pleasure of having a few acres of spare ground amid all that waste of ocean. But as no one nowadays, any more than in the time of Adam and Eve, is content with what he has got, the people of Aucutta, despising the sparkling lagoon, have dug for themselves, inland, large bathing-tanks which they have faced with blocks of dressed coral-stone, and have sometimes even furnished with neat tiring-boxes for ladies. What surprised me much about these tanks, in which the water is quite fresh, was to see swimming in them large schools of two of the very same species of fishes—a grey mullet (*Mugil* [?] *bleckeri*) and a small sea-perch (*Dules tæniura*)—that one finds in all the tidal pools of the reefs, where, of course, the water is quite salt. These fish were all quite

tame, and came to be fed in such numbers that one could catch them in a handkerchief. The sea-perch (*Dules tæniura*) I also saw in all the drinking-fountains of this island.

I had to do all my exploring and collecting at Aucutta in two short hours of daylight, for early next morning the ship was away sounding to the east and south, not to return.

The following evening (November 20th) we landed on Pitti Island, which for some reasons is one of the most interesting spots in the whole archipelago, although unfortunately my acquaintance with it is only such as I could make in one miserable half-hour of fading light.

Pitti, which cannot be much more than an acre wide, is a steep crater-shaped hillock of sand and coral-shingle, as bare as a cinder-heap, lying at the southern end of a large submerged atoll, on its extreme outer edge, so that the water on its seaward side is extremely deep. From the ship it looked like a barren sandbank and nothing more, but as our landing-party drew near, the boat suddenly became enveloped in a dense crowd of shrieking sea-birds. At first we thought that they had come to attack us, and that they could only be trying to alight on our heads and shoulders with the evil intention of picking out our eyes, but we soon found that they had merely come out of curiosity, to have a look at us. I am

glad to state that their touching confidence in us was not misplaced, for it soon appeared that these poor birds already had ills enough to bear, without flying to others that they knew not of.

On landing we found every foot of the ground above high-water mark literally carpeted with young terns of two species, many living and nearly full-fledged, many dead and rotting, and many reduced to clean-picked skeletons with only the quill-feathers still sticking to the wing-bones. There were no traces of nests, nor of any materials out of which nests could have been made, so that the parent birds must have laid and hatched their eggs on the bare sand. We soon discovered that one great cause of the wholesale destruction of young birds was the voracity of swarms of large hermit-crabs (*Cœnobita*), for again and again we found recently-killed birds in all the beauty of their first speckled plumage being torn to pieces by a writhing pack of these ghastly crustaceans. There were plenty of large Ocypode crabs too (*O. ceratophthalmus*) aiding in the carnage.

Moseley, in his *Notes of a Naturalist on the "Challenger,"* made mention of a *Grapsus* crab that he saw on St Paul's Rocks carrying off a newly-hatched tern, but such an accident does not shock one's feelings nearly so much as does the thought of full-grown young birds, nearly ready to fly out into the world and to exercise their intelligence, being overpowered

by force of numbers and slowly eaten alive by animals so far inferior in the scale. It is a sententious commonplace that Nature is cruel, and men sometimes repeat the aphorism as if half approving Nature for justifying certain doctrines about original sin, though it is doubtful whether those who talk so complacently about Nature's cruelty ever realise the facts. And perhaps it is well that this is so, for even if all of us cannot understand how Nature's apparent disregard of the individual is really only disguised beneficence, yet it is bad for anyone's moral health to consider too curiously the melancholy question,—

> "Are God and Nature then at strife,
> That Nature lends such evil dreams,—
> So careful of the type she seems,
> So careless of the single life?"

It is better not to look too closely at the tooth and claw red with ravine, and therefore we must feel glad that these, what may without improper levity be called *finishing* schools for young sea-birds, where Nature's methods are so very obvious and unadorned, are as a rule situated where few people can ever see them.

Though I had not the heart to kill any of the old birds as specimens—for, like Quentin Durward's uncle, I do not care to kill "even a dog, unless it were in hot assault or pursuit, or upon defiance given, or such like"—yet I brought away some of the best

grown young ones, in the hope that they would live, at anyrate until the first moult should reveal their specific parentage. Unfortunately the only one that did not die a natural death committed suicide, so that I am unable to say what the two species of terns were that were breeding on Pitti Bank in November 1891--and for this I fear that I shall be much blamed by my ornithological friends.

With this short and deplorably insufficient account of the Pitti atoll, I now take my leave of the Laccadive Islands. I have been careful to say no word about the political and social features of their village communities, for the very good reason, first, that I merely got glimpses of some of the islands, glimpses that were too hurried to permit me to collect the material for a proper understanding even of their zoological and botanical characters, to which I thought it my prime duty to attend; secondly, because I do not wish to speak about things that I have not heard and seen for myself; and thirdly, because I can say something of these matters when I take my readers to the neighbouring island of Minnikoy, where the social conditions seem to be very much the same as those of the Laccadives. Moreover, what had to be left undone by me had long before been very well done by others, notably by Mr A. O. Hume, whose very interesting paper, entitled "The Laccadives and the West Coast," will be found in *Stray Feathers*,

vol. iv., for 1876, pp. 413-483. A paper on the "Botany of the Laccadives," based on the collections made by the *Investigator* in 1889 and 1891, has been contributed to the *Journal of the Bombay Natural History Society* for 1892 by Dr D. Prain. This paper contains some valuable and interesting notes on the islands, compiled from the reports of various explorers.

After taking astronomical observations for checking the position of Pitti Bank, the *Investigator* proceeded, with plenty of sounding and dredging on the way, first to Calicut for supplies, and then to the island of Minnikoy. At Calicut we took on board Colonel J. Hill, R.E., the officer then in charge of Indian tidal operations, who wished to inspect the tidal observatory at Minnikoy. At this island we stayed a whole week, and at first I hoped to be able to make a fairly complete zoological and botanical survey of the place; but this hope went the way of all hopes, for as soon as the inhabitants found out that I was a doctor, they carried me off to a wilderness of sick people, upon some of whom I was even obliged to operate, taking, of course, only such selected cases — for example, the removal of sequestra of dead bone, and the slitting up of fistulous ulcers—as would be immediately benefited by surgery without requiring any complicated after-treatment. In this way a large portion of three of my meagre tale of days had to be withdrawn from the pursuit of natural history.

Almost in the same latitude with Cape Comorin, which lies about 265 miles eastward, the little elliptical ring of coral known as Minnikoy rises abruptly, out of a sea that is 1200 fathoms deep, to a height of about 15 feet above the level of the moving waters. It stands almost midway between the Laccadives and Maldives, belonging to the former group politically, and to the latter group ethnologically, and perhaps also geographically, seeing that the *Investigator* has lately discovered traces of a submarine bank, carrying between 1000 and 1100 fathoms, in the Eight Degree Channel, as the passage between the island and the most northerly atoll of the Maldive Archipelago is called. Its position is such that all the ships trading to ports east of the Arabian Sea pass close by it, and are only kept from running on to it by its friendly lighthouse, whose revolving light is visible at a distance of 19 miles.

The island itself is a narrow crescent-shaped bank, about 6 miles long and half a mile broad, piled on the south-eastern arc of the atoll, the north-western arc being a reef visible only at low-water as a broken line of rocks. Its superficial geological structure, as exposed in the pits dug for drinking-water, seems to be very simple: beneath a thin and imperfect layer of vegetable humus, there is fine coral sand; a few feet below this comes a compact and hardish crust of fine conglomerate that looks like coarse oolitic lime-

stone, with embedded bits of shell; beneath this crust of "coral stone," which, as it is easy to cut, and becomes hard when exposed to the air, makes a good building stone, there is another layer of fine sand; and then, at a depth of about 6 feet from the surface, the ground water is tapped. Upon this narrow strip of coral sand about 4000 people live, if not in such luxury and ease as to excite any envy, yet certainly not in poverty and sordid toil, but in a happy mean of sober diligence and modest sufficiency that to the white man, discouraged and dismayed by the frightful contrasts which he often sees in his own opulent societies, seems like an ode of Horace come true, or like a survival of the Golden Age.

The lagoon enclosed by the atoll is about 5 miles long and over 2 miles in its greatest breadth, and has a good main entrance at its northern end, as well as several safe though narrow passages for boats along its western side. Though it is deep, in places carrying over 6 fathoms of water, it is dangerous, by reason of numerous shoals and pinnacles of coral; but safe approaches to the shore have been marked off by beacons, for the islanders are expert in all the arts appertaining to navigation.

One lands on the beach of the lagoon near the middle of the western shore of the island, where, in a thick grove of coconut palms, there is a compact and

clean little village that houses the entire population, except a few lepers; and that which first strikes the visitor, especially if he have come from India, is the remarkable number of women that he sees, and the freedom with which, being Mahomedans, they move about uncovered. As a matter of fact, there are far more women than men on the island, and this is partly due to the circumstance that many of the males are seamen, and are away either with their own little trading - smacks, or as lascars on British steamers, leaving their wives in the position of Penelope. Not only do the women take the lead in numbers, but it is a singular fact — and specially singular in a Mahomedan community—that in all the affairs of the island, fishing and navigation alone excepted, they exercise a paramount influence.

The clue to this feminine supremacy is to be found in a survival, after the conversion of this people several hundred years ago to Mahomedanism, of one of their original Hindu institutions, by which, as among certain Hindus of the neighbouring mainland of Malabar, inheritance follows, not from father to son, but in the female line from maternal uncle to nephew. In accordance with this curious law of succession, a happy lover when he marries does not take his bride to his own hard-won home, but goes with her to his father-in-law's establishment; and any one can understand that such an arrangement is not calculated

to encourage independence of character in a husband, however much it may tend to soften and improve his manners.

The village is most carefully ordered, the houses, which stand in their own little private enclosures, and are built mostly of dressed coral stone, thatched with palm leaf, being arranged in streets. No less carefully are the inhabitants themselves grouped into a kind of septs or fratries, or *curiæ*, which have their own streets, their own bathing-tank, their own public-house or club for the men, their own ladies' club or bower for the women and girls, and their own places of worship and burial. No policemen seem to be necessary, and no police courts or prisons, for crime appears to be almost unknown; and the only magistrate that we could hear of was a headman, passing rich on a salary of something less than forty pounds a year, and wielding a sort of mild patriarchal authority.

The clubs or public-houses for the men filled me with admiration. I call them "public-houses," but it must be clearly understood that they have not the remotest affinity with any British institution of that name, seeing that the detestable and deplorable vices of drinking bad liquor and consuming ill-smelling tobacco (such as the liquor and tobacco of the bazárs of India) are not practised in them, and seem, indeed, to be unknown in this blameless abode of men. On the other hand, they may not be called "meeting-

houses," for they are not in any way consecrated to religious purposes. They are, in actual fact, large barn-like structures of palm-thatched coral stone where the men—perhaps when they have had enough of their father-in-laws' houses—come to work, and snooze, and gossip about the ordinary affairs of profane life. A broad bench runs along all four walls inside, but the most important and most delightfully-original piece of furniture is a large raft, swung horizontally from the ridge-pole by stout ropes of coir, and used on the converse principle of the punkah: that is to say, the company sit upon it, and by an occasional kick-off from the wall cause it to swing gently to-and-fro across the room, instead of sitting under it and having it swung over their heads in the placid Indian fashion. A good Minnikoy swing-punkah will accommodate a large family, unto the third generation, all at once.

The ladies' clubs, or public meeting-rooms for the women, I have preferred to call "bowers," so as to avoid a term so inconsonant as public-house or so prosaic as workroom. When one sees them full of women and girls spinning coir, with children babbling on the floor, the imagination takes a poetic flight to ancient Troy and the hall of the Iliad, where the numerous daughters and daughters-in-law of King Priam wove their embroidered robes. They are like the public-rooms of the men, but are nicely decorated

with blue and red fresco, and, of course—for such things would hardly be quite proper—they are not supplied with swings. Here the women meet by day, bringing their babies with them, to turn coir into rope, and to talk a good deal, as women sometimes will.

The private houses stand each in a little walled or fenced court, the gate of which is a stiff mat swung from a movable crossbeam on high. They are furnished far above the ordinary Indian standard of comfort, for almost all the people have swinging beds (on the national swing-punkah principle just described) with mosquito-curtains, and plates and dishes of European crockery are in common use.

The tanks, as at Aucutta, are many, and are made with much care, being faced and terraced with slabs of coral stone, and often enclosed by neat walls. They are sunk to the level of the ground-water, which, though fresh to the taste, still contains a good deal of salt, the mean of two analyses which I made giving 40 grains of chlorine to the gallon of 120 fluid ounces. The water used for drinking comes from shallow wells, and is ingeniously drawn up in a coconut shell fixed to the end of the midrib of a palm leaf: these wells, which are lined with flags of coral stone and protected by low walls, are very numerous, and there seems to be one for nearly every house.

"Pallida mors aequo pulsat pede," and from the abodes of the living we may go for one moment to the resting-places of the dead, which are kept with great care. Every grave is marked by a headstone of coral rock, nicely carved, and copiously inscribed in the Arabic character. Row upon row, close to the homes in which their simple lives were spent, and beneath the palms that nourished them and that now they in turn nourish, the rude forefathers of the hamlet sleep. With pious labour many of the head-stones are stained a delicate soapstone green with verdigris, which is made by dissolving bits of copper in palm juice that has been allowed to run on through the alcoholic into the vinegar stage of fermentation. But sentiment must always give place to sanitation, and I shall hope that the practice of burying the dead among the living, and so very close to the wells, will soon cease among these clean and virtuous children of the ocean.

# CHAPTER XIII

## AT MINNIKOY: MEMORIALS OF A MARITIME MICROCOSM

Of the Tree that Pays the Bills and the Rent. Boat-building in all its Branches. The way Tunnies are caught. The Live Bait Industry. The Social Unit: Man, Woman, and Child. Primitive Civilisation: Appropriate Speculations on the Relativity of Pleasure and Pain. The Mosquito Pest. Leprosy and Sanitary Regulations against it. A glance at the Botany and Zoology of Minnikoy. The way of a Surgeon-Fish in the Sea.

As in the islands of the Laccadive Archipelago, the principal industry of Minnikoy depends upon the supreme and universal coconut palm, beneath whose friendly shade the people dwell. The husk of the nut is macerated for many months in salt water, to separate the bundles of fibre; these natural bundles are then dried, beaten clean, and teased into separate threads; and these again are spun into thread, and are at last twisted into rope, in the manner long ago described with mediæval simplicity by Ludovico di Varthema. All this is done by women's hands, the rougher work of cutting, carrying, and storing the husks falling to the men's share. In due season the coir and nuts are carried to the mainland—mostly to

Malabar—by the small brigs of the islanders, and there they are exchanged for grain and cloth, and such frugal luxuries as these simple people use.

To the curious traveller, who loves to delude himself by trying to extricate causes from their complicated effects, and to reduce human movements to their lowest terms, Minnikoy is thus an ideal spot. For here he seems to see a few large and simple forces of nature breaking up, before his very eyes, into the multifarious pulsations of the human heart. A few lowly organisms change some of the soluble constituents of seawater into stone: the waves break down the stone and cast it up again into a little pile of dry land: the ocean currents, as they sweep by, leave some coconuts stranded upon the new-formed shore, and these coconuts, germinating, give rise after a few generations to a fund of potential energy, which a chance boat-load of colonists, tossed up probably by the same ocean currents, at length converts into the ordered movements of a fairly complex social machine.

But unrelenting care, who boards ships and who rides behind the trooper's horse, also finds her way to coral islands and climbs up the coconut palms, where, taking the form of a plague of rats, who gnaw the young nuts so that they die and fall before their time, she strikes at the very root of the islanders' prosperity. Many remedies have been proposed for this rat pest; it is said that cats, owls, ichneumons, and

even snakes, have been introduced to check it, but as generally happens when man puts himself into direct opposition with Nature before he has learned all her secrets, the original evil goes on unchanged, while the imagined remedies only become additional sources of discomfort; so that the people of Minnikoy are still asking for some means of destroying rats more regular and more automatic in action than that of hitting them on the head with a stick.

Another important industry of the Minnikoy community is boat-building, an art in which they have attained much skill. They make boats of three kinds: canoes for the lagoon and for fair weather, fishing-smacks for the open sea, and trading-brigs which are seaworthy enough to make voyages to the ports of Bengal. Their fishing-smacks, which are much used in the tunny-fishery, are fit to compare in respect of workmanship with a good Europe-built cutter: they are made partly of palm wood, partly of the white wood of the so-called "country almond" (*Terminalia catappa*), which grows plentifully on the island, and partly of teak imported from Malabar, and in shape and massive strength they have a strong likeness to an ancient war-galley.

The tunny-fishery is another of the important industries of Minnikoy. The various species of tunny (*Thynnus*), known as tunny, bonito, and albacore, are large fishes of the mackerel family which frequent the

open seas of the tropical and warmer temperate zones in large shoals all the year round, immoderately exemplifying the philosophy of Patch-breech's master, that "fishes live in the sea as men do a-land: the great ones eat up the little ones," especially where flying-fishes are concerned. They are of considerable size; the true tunny, according to Dr Günther, attaining to a length of 10 feet and a weight of over 1000 pounds. The species fished by the Minnikoy Islanders is the bonito (*Thynnus pelamys*), which they pursue in the above-mentioned fishing-galleys, these being specially built for the purpose, with a broad platform overhanging the stern. On this platform the fishermen stand and squat, some with large pots full of live bait, and others with stout rods and lines armed with a plain unbarbed spoon-bait, made of white-metal cut into the shape of a fish. When the galley, with her great lug-sail of palm-leaf matting spread, is well under way, the men in charge of the pots proceed to scatter the live bait overboard, making as they do so a tremendous splashing with their paddles so as to attract the tunnies, who are supposed to mistake the noise for the movements of a shoal of flying-fish. When the commotion is at its height, the men with the rods and lines cast their spoon-bait into the middle of it, where the spoon is almost certain to be gorged by some reckless tunny who has joined in the scramble for live bait. When a fish is caught, no time is wasted in playing

him, but he is swung on board by main strength in defiance of all the traditions of the gentle craft. We were told that on a good day, when the tunnies are biting well, a single smack will bring in several hundred fish. The tunnies—or, to be exact, the bonitos—when brought to land are cut up into gobbets, which are simply dried in the sun, without, as far as I could see, being pickled in salt; and very unattractive these lumps of dried fish look, for bonito's flesh is almost as red as beef, and dries black, nor is its odour quite the thing for a delicate nose. The fresh fish boiled is not what I should call a luxury: it has a nice crushed-strawberry colour very pleasant to the eye, but no one except a sailor would call it good for food.

The need for live bait for catching tunnies gives rise to a further subdivision of labour; for not only has the bait, which consists of fish fry, to be got hold of in plenty, but it has also to be kept alive until it is required for use. For the latter purpose, large floating cages of fine wickerwork are made for the housing of the fry, and are moored in the lagoon, so that the captive fry can live quite happily until they are wanted. These cages are as large as, but much deeper than, a jolly-boat, and as there are a great many of them, their manufacture and repair must give employment to a good many hands.

Having glanced at the island and its polity, we may next take a cursory look at the individual inhabi-

tant. And of the people in general, it must be said that they have frank and friendly manners, and look wonderfully healthy and happy, and that altogether they are a credit to their clean little island. The men are thick-set, broad-chested, and muscular, and have arms that are long and strong, as if specially developed for the purpose of climbing the smooth and intractable trunks of coconut palms and for hauling on ropes. Their faces are large and round, and expressive of much tranquility and good-humour, and their eyes are half hidden under massive brows, as if to seek protection from the glare of the sun upon the sea and upon the dazzling coral sand. From the waist downward they are clad in the same loose, gay-coloured cloth as is worn by the natives of Malabar, and for head-covering they wear either handkerchiefs of bright colour or strawberry-basket hats. They talk a language of their own, but many of them can "sling the bát"—for a terrible lascar jargon it is—in Hindustani.

Of the women we must speak, not only with the reticence due to their sex, but also with the deference due to their pre-eminent social position. Their dress is of almost quaker-like simplicity, and consists of a dull-red robe falling over a dingy white skirt; but they wear ear-rings of beaten gold, and do not despise other adornments. Their most conspicuous ornament, however, is their hair, which is worked up into a

massive chignon something after the fashion of medieval Europe. It is said, indeed, that the rank and precedence of a Minnikoy lady are denoted by the size of her head-dress—not, as according to certain philosophers they ought rather to be, by the size of the head itself. These women are as free as are those of our own country from any foolish shyness, as was shown by the fact that a party of them rowed themselves across the lagoon in a big boat for the special purpose of taking a good look at the *Investigator;* and in my medical capacity I found myself treated by all classes of women with a candour and confidence that was quite refreshingly un-Oriental.

The children of this happy isle take a very much keener interest in life than do those of India, where in dress and bearing every little girl is a miniature woman, and every little boy a miniature philosopher with the gravity of a doctor of divinity. Here the seafaring instinct is strong in the boys, who not only sail their model yachts off the shore, but also venture far out into the lagoon in little sailing-canoes to angle for fish. They manage their toy craft in a most delightful manner, sending them out to sea, and then, like young turtles, following them astride of a plank in a way that would fill an English boy with envy.

It would not be quite right to convey the impression that life at Minnikoy is all summer afternoon, though it is true that at first one is wonderfully

charmed with the quiet air of prosperity that pervades the island and with the happy combination of innocence and primitive civilisation that exists. Things, in fact, remind one of the stories of our own early ancestors, but without the violence and tyranny of those somewhat brutal times; for here as then, wealth is reckoned, not in banker's scrip, but chiefly in kind; so that, for example, the value of a fishing-smack is estimated in bags of rice. And though industry is a virtue and idleness is in the lowest degree discreditable, yet everyone is not absorbed body and soul in gain, and there is not enough accumulation of wealth for anyone to have too much of it. But although there are no feuds between patrician and plebeian or between capital and labour, yet, as in all such primitive societies, the blind elemental forces of Nature often bring about a sudden and acute desolation that is worse than any amount of the chronic discomfort that accompanies a higher civilisation. It is not so much that hurricanes sometimes uproot by the thousand the coconut palms that form the nucleus of their slender capital, and wreck the little trading-fleets that may be carrying the greater part of a season's rent and wages and interest, or even that epidemics, occasionally falling on such virgin soil, may spread like wildfire: *Omnes eodem cogimur*, and things of this sort may happen anywhere. But the peculiar terror which hangs over these small islands that rise

only a few feet above the sea-level, is that a storm-wave of more than ordinary size may make a clean sweep of them in a few minutes; and, according to Hunter, one such storm-wave in the year 1867 destroyed more than a sixth of the adult male population of Minnikoy.

I must confess, however, that I know of these tragedies only from reading about them, and that the worst evil that I myself observed was the mosquito. The island was full of these pestilent insects, whose abundance I attributed to the unlimited number of tanks and wells in which they could breed, and to the absence or paucity of freshwater fishes to feed upon their larvæ; because at the island of Aucutta, where the wells and tanks, though quite as numerous as they are at Minnikoy, positively swarmed with a little species of carp (*Barbus*), and with two species of sea-fishes acclimatised to fresh water, we did not notice any mosquitoes. So bad was the pest at Minnikoy that the inhabitants were all using mosquito-curtains to their beds, a luxury quite beyond the ideas of people of the same station of life in India.

Another of the ills which flesh is heir to at Minnikoy is leprosy, and to check its spread the elders of the people have instituted very stringent measures of segregation, thus giving another illustration of their remarkable aptitude for self-government,

and showing a respect for sanitary ordinances that is extremely rare in the East. The leper village was at the extreme northerly point of the island, and when I visited it on the 8th December 1891, I found there a few squalid huts, a well of drinking-water, and thirteen miserable human beings, who, when they saw me, prostrated themselves on the ground with the most piteous gestures of supplication. Eight of them were women, of whom none were old and one was a comely girl of about eighteen years, four were young men, and one was a small boy of about ten: most of them were suffering from the anæsthetic form in its mutilating phase, but two had the typical tuberous form. One young man, who was spokesman for the rest, said that they were all starving, and that they had been sent there only to die; but it must be confessed that neither his own nor his unfortunate companions' appearance vindicated this statement, and he admitted that a supply of food was deposited periodically on a certain ominous boundary-stone, and that the reefs hard by were full of crabs and fish and trepang. There was no guard anywhere near the village, and no sort of watch seemed to be set upon the lepers, and yet by the working of some unseen but well-understood restraint the poor wretches were kept in their place as securely as if they had been bound. I questioned them on this point, but could get no satisfactory answers from them, though they were all

agreed that they would not on any account venture beyond that boundary-stone of ominous appearance.

So far as I could pay attention to the botany and land zoology of Minnikoy—for as a marine zoologist I considered that my first duty lay with the reefs and lagoon—I did not discover anything of peculiar interest. Though the island is in the main covered with coconut palms, there are a good many "country almond" trees (*Terminalia catappa*) and there is a fairly abundant undergrowth of shrubs and creepers, *Ipomœa* and sweet-scented screw-pine predominating in the neighbourhood of the shore. Among the cultivated plants the areca-nut palm and the betel — two plants whose products, enkindled by a morsel of quicklime, form the curious aromatic quid which the Oriental so loves to ruminate—are, of course, to be found. But the feature which distinguishes Minnikoy botanically from all the Laccadive Islands is the great abundance, at the western end of the island, of mosses and lichens on the trees, and of treacherous sheets of the slimy, dirty-looking *Nostoc* on the ground.

Though rats are abundant, they keep to the crowns of the coconut palms, and their undesirable existence is only evidenced by the young, half-gnawed coconuts that one sees lying about everywhere. The animals that one sees most of are land-crabs, by whose burrows (mostly those of *Ocypoda cordimanus*), the ground is honeycombed: wherever there is a well,

there in the crannies of its walls *Geograpsus grayi* will be found skulking; and, lurking under fallen timber, a close search will often bring to light *Metasesarma rousseauxi*, whose mottled colouring is so like that of dead lichen-spotted wood as to make this little crab almost invisible. Everywhere innumerable hermit-crabs are to be seen staggering about: a common species is *Cœnobita rugosa*, one individual of which was of such large size that it could not find a shell big enough for a house, and so had accommodated itself with an empty coconut: another individual was so big that it seemed to have given up hope of finding a house, and was wandering about recklessly with its tail behind it all unprotected, just like a little *Birgus latro*. Mosquitoes and flies were very troublesome, but the only insect that I shall here set down was a little white-and-green Mantis found in the large white-and-greenish flowers of a Pancratium: so exactly matched were the colours of the insect and the flower, that had I not happened to shake the creature out of its ambush, where it was lying in wait like a spider for its prey, I should never have noticed it. Lastly, I must not forget to mention some little gastropod mollusks, probably a species of *Succinea*, that I found crawling on the moss that encrusted the palm trunks; but, though I have looked everywhere for the specimens that I collected, I cannot now find them.

The sea off Minnikoy was of marvellous clearness. Our anchorage was off the western reef of the atoll, and here in 6 fathoms one could literally have seen a sixpence lying on the bottom, and even when, as the tide changed, the ship swung into 12 fathoms, all the details of the sea-bottom could still be plainly made out. In such limpid water angling was not a very hopeful occupation, but we managed to hook some of the strange-looking and foul-feeding surgeon-fishes (*Naseus tuberosus* and *unicornis*) that used to swarm round the ship. In these curious fishes the tail, just near the root of the tail-fin, is armed on either side with several broad, stiff, out-standing plates, whose edges are so sharp that they can inflict a wound as clean and deep as that made by a surgeon's knife. The very first one that we caught gave us ample proof of its formidable powers in the cutting line, for with one sweep of its tail it laid clean open the palm of a lascar boy who incautiously took it into his hand.

On December 12th we left Minnikoy, taking with us good store of the turtles for which the island is so justly famous, our immediate destination being Colombo, there to take in coal preparatory to resuming our survey of the Coromandel coast.

## CHAPTER XIV

### ZOOLOGICAL GLEANINGS ON THE GODÁVARI COAST

Mortal Illness of Commander Hoskyn. The Scenery of the Godávari and Kistna Deltas. Viviparous Sting-rays. The Genealogy of the Bat-ray. Habits of the Red Ocypode Crab: Musical Powers of Ocypode Crabs. The Epic of the Fiddler-crab. More Deep-sea Dredging. L'Envoi.

FROM the day that I rejoined the *Investigator*, sharpened by five months of pathology and out-patients, I had noticed that our skipper was not himself. Though he did his work as usual, and made no complaint, yet he was pale and pinched, and every day he seemed to get worse, for a small ship in the Laccadive Sea is no place for anybody but a strong man. Unfortunately, you cannot put the captain of one of His Majesty's ships on the sick-list unless he makes the first advances himself, and so all I could do was to get his shore friends informed that I did not like his looks, and thought that he ought not to stay in the ship. This took some time of accomplishment, and it was not until we reached Colombo, on the 15th December, that I learned that my schemes had taken effect, by his asking me to

arrange about a medical board. We left Colombo on the 18th December, and after a stormy passage against a powerful current, the *Investigator*, whose strong point never was speed, at last got into Madras. There I brought Captain Hoskyn before a medical board, who found that he was suffering from phthisis, and ordered him away on leave at once. The poor fellow rejoined his wife at Poona with the idea of eventually going on to Egypt or Algiers, but before he could get away from this country he died, to the very great grief of us all, for a kinder, truer man, and a cheerier commanding-officer never stepped. I shall always retain the kindliest feelings for him, for I cannot imagine a man who, while making no pretensions to any special interest in zoology, could yet be more indulgent to the naturalist's department, or more tolerant of the noise and mess —so utterly opposed to all the traditions of the British navy—which are inseparable from dredging operations.

From Madras we proceeded northwards to Bimlipatam, there to provide ourselves with a surf-boat and crew, for on this exposed coast the surf, even when an ordinary ship's boat can live in it, is always boisterous enough to make landing in such a boat a matter of difficulty and risk, especially when surveying instruments have to be thought of. Having got our boat, we went down the coast again to Coconada,

where our survey was to be carried on southwards, in continuation of the work of the year before, and in this desolate part of the world we remained for three months, until the middle of April, surveying the deltas of the Godávari and Kistna.

I have already, in speaking of the dangerous Sacramento shoal which lies off one of the mouths of the Godávari, said something of the peculiarly dismal character of this piece of coast, where the sea is often so shallow and the land so low that the ship cannot come in near enough to see survey-marks ashore, and where, as a consequence, her positions have to be fixed by triangulation from beacons moored far out amid the shoals. Such a sea, full of mud and richly charged with organic matter from the land, of course abounds in animal life of certain kinds, such as crustaceans, fishes, and sea-snakes; but it is of little use to trawl for them, as the trawl only sinks into the soft bottom and gets choked, so that in default of better occupation, I was often obliged to make a day's work out of the washings from the tow-net. Whenever I could land and get among the native fishermen, who at this fine season of the year haul enormous seines all along the coast, I did so, much to my benefit; and on many occasions I attached myself to a coast-lining party, in the hope of finding something worth having along the beach, or of getting a shot at wildfowl. In this way I picked up a fair knowledge of

the coast, and made a few zoological observations of some interest.

As for the coast, it is very much like what one imagines of those plains of the black and sluggish Cocytus, which, as Horace warns the pious Postumus, we must all one day cross. First comes an interminable mud swamp, and then an interminable waste of sand-dunes, held together by the leather-leaved convolvulus (*Ipomœa*), and the long, bristly strands of the "sea-pink," yet slowly drifting landwards; with here a small village of rude huts, and there a grove of coconut palms. Of course, if one goes a few miles inland, the scene is very different, for then one strikes that vast sea of rice-fields, which has been called into existence mainly by the irrigation-engineers of the British Government.

At my visits to the seine-nets I was glad to find that the things I most wanted, namely, sharks and rays, were regarded as useless and unprofitable by the fishermen, who let me take what I liked; but they objected to my pickling any of the multitudes of sea snakes which they inadvertently captured. These they always carefully put back into the sea, not for pity's sake, but to appease the offended gods. So far did their superstitious reverence for these venomous reptiles go, that even when—as happened to a poor little boy one morning, shortly before my visit—a person was bitten and died, their resentment was not in the least aroused.

From these pious but deluded people I got many good things that they meant to leave to the crabs, and kites, and jackals. Among them was a large female sting-ray, over 9½ feet long, of the species *Trygon bleekeri*, and, lying unborn in her oviduct, I found a young one, 3 feet in length. The mucous membrane of the oviduct was shaggy, with vascular filaments dripping with milk, and on microscopic examination I found that each filament was provided with superficial muscles, whose contraction must serve to squeeze the milk out. Some such mechanism is undoubtedly necessary, seeing that the young one has no power of extracting the secretion for itself. On examination of the young one, the mother's milk was found inside the modified first pair of gill-clefts or spiracles (the other gill-clefts being tightly closed), and also in large clots within the spiral valve of the intestine, so that there can be no doubt that in these viviparous rays the unborn young one may be said to "drink its mother's milk" like a mammal, even though the milk-like secretion does not go in at the mouth, but by channels homologous with the ear-drum of air-breathing vertebrates.

I also got several female specimens of the small sting-ray (*Trygon walga*), in three of which there were young ones and milk, the milk-filaments being impacted in the spiracles of the young one, as in *Pteroplatæa micrura*. All these specimens were found

in shallow little tidal pools lying behind natural break-waters of sand, and it seemed as if this comparatively safe situation had been deliberately chosen by the mother as a nursery for her expected family, as in the opinion of Professor M'Intosh is the case with the viviparous Blenny of northern seas.

Females of the short-tailed bat-ray (*Pteroplatæa micrura*) in all stages of pregnancy were found, the most interesting of all the specimens being one containing an embryo about 1¼ inches long, still attached to a yolk-sac full of unconsumed yolk. Regarding this embryo two facts of very considerable importance were elicited, one relating to the yolk-sac, the other to the embryo itself. With respect to the yolk-sac and its stalk, the noteworthy feature was that they contained no blood-vessels for absorbing the yolk, such as are generally found in all yolk-sacs, and yet the yolk was being consumed, for small particles of it were found passing along the hollow of the stalk of the sac into the embryonic intestine into which the stalk opens; besides which, the whole yolk-sac was enveloped in a cloud of long, vascular filaments springing from the gill-clefts of the embryo, and to these external branchial filaments no other function could be assigned than that of absorbing the yolk in some way. The little embryo also revealed some interesting secrets of its own genealogy. It was shaped not like a skate, but more like a shark, having a shark's snout and a shark's tail; like a

shark also, it had its gill-clefts placed on either side of its head, and not on the under-surface of its body as they are in all skates and rays: unlike those of most sharks, however, were its pectoral fins; for these, instead of standing out at right angles to the body, were produced to form a pair of flaps running forward with a slight twist, one on either side of the head. If we could have seen the embryo at a later stage, we should have found that these two flaps had fused with the head, so as to push the gill-clefts down to the under surface and to produce the broad, disk-like body characteristic of the skates and rays. There are some rays, such as the sea-devils (*Dicerobatis* and *Ceratoptera*), in which the flap-like anterior prolongations of the pectoral fins are not entirely fused with the head, but stand out in front of it like a pair of horns: these, judging from the form of the embryo of *Pteroplatæa micrura*, may perhaps be regarded as "unfinished" rays. Again, there is a peculiar shark—the monk-fish or angel-fish (*Rhina squatina*)—in which the front part of the pectoral fins have, as in the early embryo of *Pteroplatæa micrura*, the form of a pair of flaps enveloping the sides of the head, but not fused with it: this singular shark may perhaps be regarded as venerable first cousin of the ancestor of all the skates and rays.

The sandy stretches along the Godávari and Kistna coasts are copiously honeycombed with the burrows of the red ocypode crab (*Ocypoda macrocera*) as are the mud

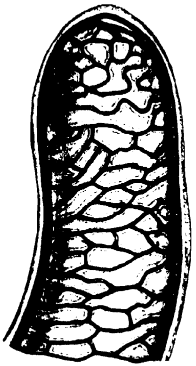

FIG. 24.—Tip of a milk-secreting filament of a Bat-ray (*Pteroplatura micrura*), showing the arteriole, and the capillary network in the meshes of which the milk-glands are embedded. Magnified forty-two times.

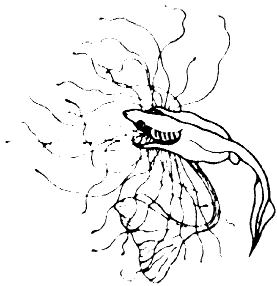

FIG. 25.—Early shark-like embryo of the Indian Bat-ray (*Pteroplatura micrura*), natural size. Only a few of the external gill-filaments are represented.

[*To face page* 212.

[illegible] with those of the smaller fiddler-crab (*Gelasimus annulipes*). Both these crabs are amphibious, living in fact more on dry land than in the sea, and both are remarkable for their activity and intelligence: indeed, after much observation of them, I am inclined to think that the crabs of these two genera are about the most gifted members of the whole crustacean class, and among Arthropods are inferior to none but the social insects. Though they have seven pairs of gills, which are well developed and functional, yet the gills do not nearly fill the enormous gill-chambers, and it is mainly by means of these capacious gill-chambers and by the thick and vascular membrane which lines them that Ocypoda and Gelasimus are able to breathe on dry land: a special air-slit, which opens between the bases of the second and third pairs of running legs and is well protected by a thick filter of hairs, allows air to enter and leave the gill-chambers.

In the adults of all but one of the species of Ocypoda the eye-stalks are produced beyond the eye itself, to form a pair of long slender horns, and these are particularly conspicuous in *O. macrocera.* What the use of these horns may be we do not exactly know, but it is possible that they may serve as organs of touch, seeing that the antennæ are rudimentary in this genus. Again, in both sexes of this remarkable genus the nippers, or chelipeds, are singularly unequal in size, and in all the species but one there is present on the inner surface

of the "hand" of the larger cheliped a transverse row or key-board of fine teeth, which, when the cheliped is flexed, can be made to play against a ridge or another row of teeth on its "arm" or ischiopodite, much as a man might rub one side of his chest with the palm of the corresponding hand. The whole mechanism, except that it is on a larger scale and has a more finished appearance, is very much like that by means of which crickets and grasshoppers produce their shrill music, and no one has ever doubted that it is used for the same purpose, although it seems that very few people have actually heard it in action. I myself watched *Ocypoda macrocera* for three seasons without ever learning that it made any sounds such as this large and efficient-looking musical apparatus seems capable of producing, and I was beginning to think that the structure must, after all, have some quite other function, when one morning, while coast-lining with Lieutenant Huddleston on the sandy wastes of the Gódávari delta, I at last, like Ancient Pistol, heard with ears that which I had so long been waiting for. That is to say, I heard a noise very much like that which an angry squirrel makes, and discovered that it came from a red ocypode crab into whose burrow another individual had trespassed.

In order to understand the matter, it should be known that these crabs, although they do not seem to have any social co-operation, are gregarious, and

THE MUSICAL STRAND-CRAB OF THE COROMANDEL COAST.

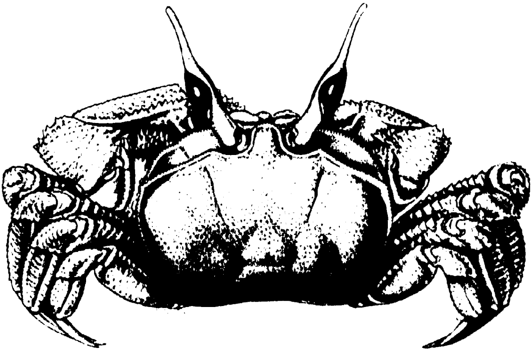

FIG. 26.—The Red Ocypode Crab (*Ocypoda macrocera*), in a crouching attitude.


FIG. 27.—Larger cheliped of the Red Ocypode Crab (*Ocypoda macrocera*), showing the stridulating mechanism, possessed by both sexes —(*a*) the key-board, on the inner surface of the "palm"; (*b*) the plectrum or scraper, on the inner surface of the "arm."

[*To face page* 214.

that each one has a burrow of its own. Though they may sometimes be seen marching in battalions across the sand, yet as a rule they stay close to their burrows, methodically searching and sifting the surrounding sand for any food that may have been thrown up by the tide, and flying to their burrows with headlong speed when alarmed. At first sight one does not understand the necessity for so much wariness, and for such a deep system of entrenchment, for the creatures seem to hold undisputed possession of the entire shore; but as a matter of fact they are preyed upon all day long by Brahminy kites, and when the jackals come out in the evening, by them. Now, although each crab may on ordinary peaceful occasions know its own home, yet when a crowd of them are running for their lives they may sometimes, one would think, act on the devil take the hindmost principle and try to squeeze into the nearest burrow. But, as ancient philosophers do report, things may be done upon occasion which it is inexpedient to make a habit of doing, and this seems to be one of those things; for if many crabs made a practice of crowding into one small burrow they would certainly run the risk of being suffocated, if not crushed to death outright. It seems probable, therefore, that it would be advantageous to the species as a whole if the rights of property in burrows were rigidly respected, and if each individual member possessed some means

of giving notice that its burrow was occupied—or, as Mr Stebbing has expressed it, that it was "not at home" to callers; and I think that this consideration gives us a clue to the use of the stridulating mechanism. At anyrate I was often able, after my first accidental discovery, to elicit the sound, by catching one of these crabs and forcing it into a burrow which I knew was already occupied: the intruder would never go far in, but would crouch just inside the mouth of the burrow, and if it were made to travel deeper, then the voice of the rightful owner would be heard in indignant remonstrance from the depths. It does not follow from this argument that the vocal mechanism *originated* for this special purpose, or that it has no other use; this, for instance, may not be its sole function in the case of the large grey ocypode crab (*O. ceratophthalmus*), which, so far as my observation goes, does not always burrow deeply, and yet possesses a particularly perfect vocal organ, and, according to Dr A. R. Anderson, can make a loud croaking noise with it. By the grey ocypode crab it may perhaps be used for scaring enemies: this is an obvious explanation; but that enemies, as goodman Dogberry's watch might urge, will not always be scared by noises is, I think, evidenced by the following digression.

In my aviary I have had for a long time a white-cheeked bulbul, who is as bold as he is fastidious,

always pushing himself forward when the daily box of grasshoppers is brought to the cage, and always refusing any but the softest and greenest. One day I thought I would surprise, and perhaps even terrify him, by letting loose, instead of the accustomed grasshoppers, a fine, healthy, new-hatched imago of the larger Indian death's-head moth (*Acherontia lachesis*) a creature that, when interfered with, makes with its proboscis a sharp and alarming strident sound. The bulbul attacked it at once, and though the moth stridulated loudly and fought vigorously, the bird never once flinched, and was soon tearing the dead body of its noisy victim to pieces.

The crabs of the genus *Gelasimus*, commonly known as fiddler-crabs, are very closely related to the Ocypodes: they live together in the same way in large companies and lead the same sort of life, except that they prefer mud flats to sandy shores; and they are exposed to the same enemies, whom they avoid in the same way, by burrowing. But whereas among the Ocypodes both sexes are exactly alike, among the Gelasimi the male and female are very different from one another. The difference between the two sexes is most emphasised in the nippers or chelipeds, for while in the female these are slenderer and much shorter than the legs and are used chiefly in feeding, in the adult male the "hand" alone of one of them

is often twice as big as the body. Many uses have been assigned to this enormous lop-sided organ: some say that it is used as a stopper to barricade the mouth of the burrow, others that it is a sort of cradle or bridal-couch upon which the female reclines—the male in this case literally bestowing his hand upon the female; but from observations of *Gelasimus annulipes*, the species which most frequents the Godávari and Kistna mud-flats, I believe that it primarily serves as a war-club—for the males indulge in interminable tournaments for the hand of the female; and secondarily—for it is of a most beautiful cherry-red colour—as an ornament to attract and delight the latter capricious sex.

Landing one afternoon in March upon a cheerful mud flat of the Godávari sea-face, I was bewildered by the sight of a multitude of small pink objects twinkling in the sun, and always, like will-of-the-wisps, disappearing as I came near to them, but flashing brightly on ahead as far as the eye could reach. It was not until I stayed perfectly quiet that I discovered that these twinkling gems were the brandished nippers of a host of the males of *Gelasimus annulipes*. By long watching I found out that the little creatures were waving their nippers with a purpose—the purpose apparently being to attract the attention of an occasional infrequent female, who, uncertain, coy, and hard to please, might be seen unconcernedly sifting

## FIDDLER-CRABS AND THEIR IMMODERATE DIFFERENCES.

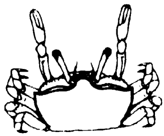

FIG. 28.—Female of the Fiddler-Crab of the Godávari and Kistna mud-flats (*Gelasimus annulipes*). Both the chelipeds are small, and are used only in feeding.

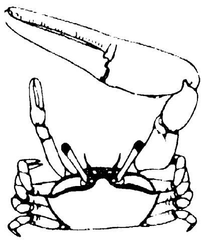

FIG. 29.—Male Fiddler-Crab (*Gelasimus annulipes*), of the Godávari and Kistna mud-flats. One of the chelipeds is enormously enlarged, and has the "hand" brilliantly coloured, so as to be at once a weapon and an ornament in the prolonged and savage tournaments in which these little creatures engage to win the favour of the opposite sex.

[*To face page* 218.

the sand at the mouth of her burrow. If this demure little flirt happened to creep near the burrow of one of the males, then that favoured individual became frantic with excitement, dancing round his domain on tip-toe and waving his great cherry hand as if demented. Then if another male, burning with jealously, showed a desire to interfere, the two puny little suitors would make savage back-handed swipes at one another, wielding their cumbrous hands as if they had no weight at all. Unfortunately, though I spent many a precious hour on the watch from time to time, I could never see that these combats came to anything: the males seemed always to be in a state of passionate excitement, and the females to be always indifferent and unconcerned; and though the dismembered chelipeds of vanquished males could often be seen lying on the battlefield, I never had the satisfaction of beholding a good stand-up fight fought out to the sweet end, or a female rewarding a successful champion with her heartless person.

During this survey of the Godávari coast we made six successful hauls of the reversible trawl in deep water, under the auspices of our officiating commander, Lieutenant G. S. Gunn, R.N. In the depths between 250 and 400 fathoms, where the bottom consisted of dark-coloured unconsolidated ooze, we fell in with many kinds of deep-sea eels and fishes

of the genus *Macrurus*, and on one occasion we brought up a multitude of large brittle-starfishes (*Pectinura conspicua*); but in deeper water, up to 750 fathoms, where the bottom was consolidating under pressure into a stiffish clay, we encountered fields of sea-urchins (*Phormosoma*) and large simple corals (*Flabellum laciniatum* and *japonicum*). Among the more interesting contents of the trawl at this time, I must mention an empty egg-shell of a *Chimæra*—a deep-sea shark not before known to exist in tropical seas—and a dwarf species of *Cerianthus*, a genus of sea-anemones of great rarity in Indian waters.

Towards the end of April, as the weather began to grow unsuitable for survey-work, the ship's head was turned towards Bombay again; and on the way home we trawled twice in deep water, off the Malabar coast, getting among other things a stalked sea-lily, some specimens of the brilliant many-rayed deep-sea starfish *Brisinga*, and a spoon-worm (*Sipunculus*), with eggs lying free in its body-cavity.

Early in May we reached our old moorings, and soon afterwards I ceased to belong to the ship's company, though my connection with the Marine Survey, so happily begun in November 1888, has continued in an unofficial form up to the present day.

It would hardly become me to conclude this

short account of my personal connection with the *Investigator* without a word of acknowledgement to that old and honourable service—the Indian Medical Service—which has given me so many opportunities of carrying on the fascinating study of zoology without depriving me of any of the rights and privileges of my own proper profession.

It is said that, owing to the multiplication of returns and reports and the consequent increase of quill-driving and dry office-work, and owing also to the fact that while the cost of living has become doubled the sterling rates of pay have, by reason of the diminished value of the rupee, decreased, the service is not what it was: that neither for the man who purposes to lay up for himself the corruptible treasures of earth, nor for the clear spirit who merely desires a fair amount of leisure in order to strictly meditate the thankless Muse, is the service of to-day comparable to the service of the palmy days of Buchanan-Hamilton, Cantor, Carter, Day, Falconer, Fayrer, Jerdon, M'Clelland, Patrick Russell, Spilsbury, G. C. Wallich, and other zoological worthies of enduring reputation. Yet to a young medical man of scientific tastes the Indian Medical Service still affords both material and opportunities for scientific research such as, I believe, he will not find in any other part of the world, unless he be possessed of considerable private means.

Finally, I cannot bring the narrative portion of this little volume to a close without recording my obligations to my old shipmates of the Royal Indian Marine who made life in the *Investigator* so pleasant. When I remember how cheerfully they sometimes forewent their well-earned rest in some safe anchorage in order that the ship might drift all night with the tangle-bar down for my sake, and how they not only tolerated all the smells and mess for which I was responsible, but also would always, though fully occupied with important work of their own, bring me everything that they thought would be acceptable to a naturalist, I feel that I am indebted to the *Investigator* for much that was worth learning besides marine zoology.

# PART II

## THE DEEP-SEA FAUNA OF THE INDIAN REGION

"This great and wide sea, wherein are things creeping innumerable, both small and great beasts."—Ps. civ. 25.

## PRELIMINARY NOTE

Numerous incidental references have already, in the preceding pages, been made to the depth and temperature of the Indian seas, and more exact statements on the same subject will be found in one of the Appendices: it may not be amiss, however, to prefix to this short review of the local deep-sea fauna a brief summary and iteration of the matter.

*The Andaman Sea*, which is the basin enclosed by Burma and the Malay Peninsula on the north and east, and by the Andaman and Nicobar Islands on the west, has, as far as our present knowledge goes, a maximum depth of about 1600 fathoms, but the average depth of its open parts is about 1100 fathoms. The average temperature of its surface waters is about 80° Fahr., but the temperature of its depths below 1000 fathoms is somewhere about 41° Fahr.

*The Bay of Bengal* is that great reach of the Indian Ocean whose waters wash the shores of Ceylon and British India from the meridian of 80° E. eastwards as far as the Andaman-Nicobar chain. It is a vast submarine plain, shelving very gradually to a depth of 2300 fathoms at its mouth, its unbroken monotony being relieved, so far as we know, by only one elevation. This elevation, which may be compared to a great isolated hill 5820 feet high, is known, after Commander Alfred Carpenter, R.N., as Carpenter's Ridge: its summit, which rises to within 1370 fathoms of the surface, lies about 200 miles west by south of Great Nicobar Island. The average temperature of the open

surface waters of the bay is about 80° Fahr., but the temperature of its abyssal depths is less than two degrees above the freezing-point on the Fahrenheit scale.

*The Laccadive Sea* is that part of the Arabian Sea which lies between meridian 72° E. and the Malabar coast. Its greatest depth is about 1500 fathoms, and while the temperature of its open surface waters is about 80°, its abyssal temperature sinks to between 35° and 36° Fahr.

## CHAPTER XV

### OF DEEP-SEA FISHES IN GENERAL, AND OF THOSE OF THE INDIAN OCEAN IN PARTICULAR

In the former, rather disconnected, narrative part of this little book, I purposely refrained from anything but a cursory notice of the deep-sea fauna which it was one of my official duties to investigate, so as to avoid offending any possible readers who are not greatly interested in the subject. In the present part, my aim is to give a general account of the forms of life, so far as they are known, which inhabit the seas of India at depths ranging from 100 to 2000 fathoms, an undertaking which, though involving more matter with less art, will not, I hope, be altogether weary and unprofitable.

I shall begin with the fishes instead of with the animals of the lowest and simplest kind, because to most people fishes are the best appreciated animals that live in the sea. Indeed, the word "fish" in itself has as many pleasant and important associations as any noun-substantive in the English language. To the epicure it suggests a dainty and wholesome diet; to the

angler it recalls hours of serene communion with Nature, and days of happy release from all the cares of a weary world; to the Christian it brings up such sacred traditions as the feeding of the multitude in the wilderness, the payment of the tribute money at Capernaum, the miraculous draught in the Lake of Gennesaret, and the call of those humble toilers who were chosen to be the first hearers of the word; while the mind of a more curious turn may revert to the fish that foretold the doom of the too-fortunate Polycrates. Again, to those whose thoughts take a practical bent, it speaks of several important industries; and to those who do not forget the primeval connection between fishermen and sailor-men, it tells, even as it did in the days of the Virgin Queen, of "the increase of the navigation of England, of which, both for wealth and safety, enough cannot be said."

According to Dr Günther, before the voyage of the *Challenger* (1872-1876), scarcely thirty species of deep-sea fishes were known. At the present day, if we also include those oceanic fishes which ordinarily live some distance below the surface, we have become acquainted with more than a thousand species, most of which have been discovered by H.M.S. *Challenger*, by the United States survey-ships *Albatross* and *Blake* and by other vessels of the United States Fish Commission, by the French ships *Travailleur*, *Talisman*, and

*Caudan*, by the Prince of Monaco's yachts *Princesse Alice* and *Hirondelle*, by expeditions from Norway and Denmark, and by the *Investigator* herself.

But, as Dr Günther has pointed out, although these fishes exhibit numerous characteristic modifications for life under peculiar conditions, yet they all belong to groups with which we are perfectly familiar. Now this is hardly what we should have expected on the theory that the great ocean basins have remained unchanged, or little changed, from the earliest geological ages. If this theory be true, we should rather expect to find that the fishes of the depths belonged to ancient groups, which ages ago had become modified, beyond any fear of displacement by more modern invaders, for the special conditions of abyssal life, but which, in other situations, where the conditions of life had been subject to constant change, had long ago become extinct. We should, in fact, look to the depths — as, indeed, some of the older zoologists actually did look — for a series of living fossils that would fill many gaps between existing orders of fishes.

But if we do not find that the abysses are peopled by strange relics of the Age of Ganoids, it is certainly true that among the fishes of the deep sea we find, on the one hand, a suggestive number of survivors of groups—such as the Berycoids, and Trichiuroids, and marine Physostomes — which appear to have passed

their prime, and on the other hand a suggestive absence or paucity of some of the more modern marine groups, such as the Lophobranchii and Plectognathi; so that it may fairly be said of the fish-fauna of the depths that, as a whole, it has a slightly more antiquated make-up than that of the littoral,* and we shall notice hereafter that the same thing holds good of the the stalk-eyed Crustacea, and perhaps of some other groups also.

We have already referred to the peculiar conditions of life in the depths of the sea; they are such as are determined by greatly increased pressure, by absence of sunlight and consequent absence of all vegetation except bacteria, by permanent low temperature, and perhaps by diminished supplies of oxygen.

One of the effects of the enormous increase of pressure is that bones and muscles which at the ordinary pressure of the atmosphere (14.7 lbs. to the square inch) are so fragile as hardly to hang together, are perfectly solid and coherent, this being the inverse statement of the fact that when a deep-sea fish, which presumably led an active life, is brought to the surface, how gradually and carefully soever, its bones are often like so much touchwood, and its muscles like so much rotten pulp, while its eyes are burst from their sockets,

* This proposition expressly refers only to *marine* fishes, not to freshwater fishes, among which a few "living fossils" still survive, giving the freshwater fauna a more archaic connection than any part of the marine fauna, as far as fishes are concerned.

TWO VERY DELICATE DEEP-SEA FISHES.

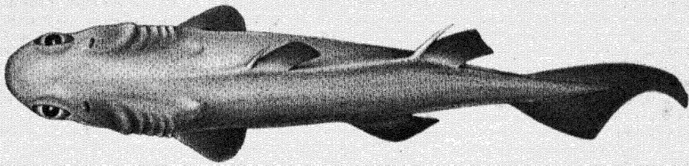

FIG. 30.—*Centroscyllium ornatum*, a Spiny Dog-fish, from 285-690 fathoms; much reduced.

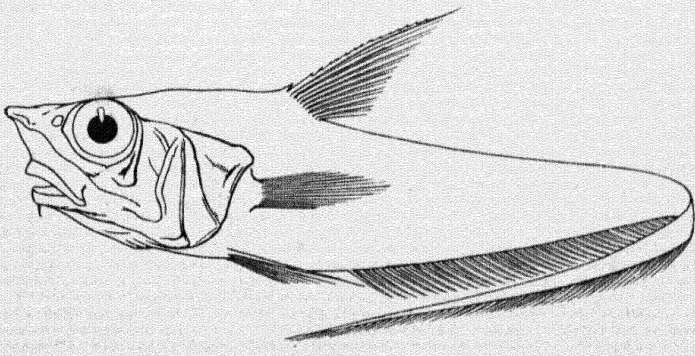

FIG. 31.—*Macrurus investigatoris*, from 193-490 fathoms; one of the commonest deep-sea fishes of India.

[*To face page* 230.

and its viscera are often blown out of the body-cavity by the expansion of the air-bladder.

The immediate results of the absence of sunlight are not so easy to trace, because there is no doubt that the depths of the sea are more or less lit up by the phosphorescence of their own inhabitants. If the bottom of the sea were quite dark, we should expect that the fishes living there would, like those of underground caverns, be blind. But, unfortunately, we can seldom be sure, of any given fish brought up in the dredge, either that it actually came from the bottom, or that, if it did, it really passed the whole of its life there and never at any season removed into regions that are in some way or other illuminated: and so long as we are uncertain on these points we must not be surprised to find that the majority of deep-sea fishes have eyes, and that many of them have eyes of extraordinary size. Where, however, we bring up, from depths to which no sunlight can penetrate, fishes that, either from their habits or from their structure, we know *must* have lived on the bottom and nowhere else, we often do find, especially if such species have no means of producing their own light, that they are either quite or nearly blind. Examples of such species will be described further on.

One result of the absence of daylight is that many of the deep-sea fishes have in a high degree the power of manufacturing their own light. In most of

the species the mucous-canal-systems of the head and lateral line are surprisingly developed, and it is thought with good reason that the mucous thus so copiously secreted is luminous. But many of the species also possess special phosphorescent organs: these may be scattered, but are more commonly arranged in definite lines along the mucous canals of the head and trunk, and they are of every degree of perfection, from a simple pearly patch of skin up to a structure having a strong resemblance to a miniature "bull's-eye." These luminous organs, it should be mentioned, are sometimes used, not as search-lights, but as lures to attract prey. Such is supposed to be their function in the case of the deep-sea Anglers, where the light is placed at the tip of the modified fin-ray which in other Anglers forms the rod and bait.

Another result of the darkness, or dimness, of the depths is that many deep-sea fishes, especially those species in which the eyes are small, are thrown back, in compensation, upon the sense of touch, and this has in some cases led to an extraordinary development of some of the fin-rays, which may even be transformed into long antenna-like feelers, by whose means, as Moseley has expressed it, the possessor gropes its way in the dark, like a blind man with a stick. There seems also to be some reason to believe that, in addition to any other functions which it may

possess, the elaborate mucous-canal-system of deep-sea fishes is part of a specially-delicate tactile mechanism.

The absence or deficiency of sunlight, which makes colour-markings of no moment, is very reasonably supposed to explain the facts that the majority of deep-sea fishes are of a uniform—and usually sombre—colour, and that only a minority are banded, striped, or otherwise marked in definite patterns; but this again is a subject that is open to much discussion, by reason of our inability rigidly to define its compass. Our observations in the *Investigator* extend to 168 species which have been dredged below the 100-fathom line: of these, fifty-two were black, or some shade of blue, or purple-black; fifty-six were some shade of dull brown, ten were silvered over a blackish or brownish ground colour, ten were bright silver, and four were grey; making a total of 132—or 78 per cent.—simply-coloured species. Again, fourteen species, mostly among those living between 100 and 250 fathoms, were of a nearly uniform red or rosy hue, this very possibly being the colour of the daylight—like the sun's disk in a fog—at those depths. On the other hand, only eighteen species, and these for the most part species found near the 100-fathom line, were striped, or marked with recognisable patterns, and only four species were brilliantly variegated with many colours.

That the true deep-sea fishes, namely those tha live permanently in the still seclusion of the abysses consume less oxygen than their shallow-water relatives is inferred from the fact that their gill-plates are sc much smaller. In some cases, indeed, as in many o the deep-sea Anglers, the gill-plates are reduced, noi only in size, but also in number, being present on only two of the gill-arches on either side.

Owing to the fact that, as a consequence of the eternal darkness, there is no vegetation in the great depths of the sea, the abyssal fishes are all carnivorous. It is perfectly true, of course, that most shore fishes are carnivorous also, but nowhere do we encounter such an enormous gape of mouth, such a formidable array of teeth, and such insatiably-distensible stomachs as we do among certain fishes of the deep sea; but this is a matter to be referred to later on.

Before the year 1881, when the *Investigator* began her explorations, nothing at all was known of the fishes that dwell in the depths of the northern reaches of the Indian Ocean, for the *Challenger* seems to have left this part of the sea to local naturalists. Since then, however, we have learnt that these depths are thickly populated with fishes, the majority of which resemble the deep-sea fishes found in other parts of the world, and are therefore quite unlike the familiar shore fishes of the Oriental region. Thus among the

## TWO DEEP-SEA FISHES WITH QUITE RUDIMENTARY EYES.

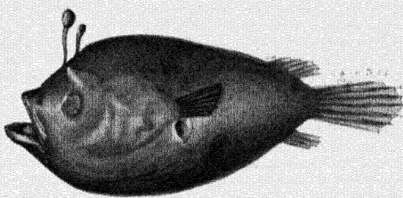

FIG. 32.—*Onirodes glomerosus*, a deep-sea Angler, with rudimentary subcutaneous eyes. The first dorsal fin-ray is modified to form a luminous lure. From the Bay of Bengal, 1260 fathoms; enlarged.

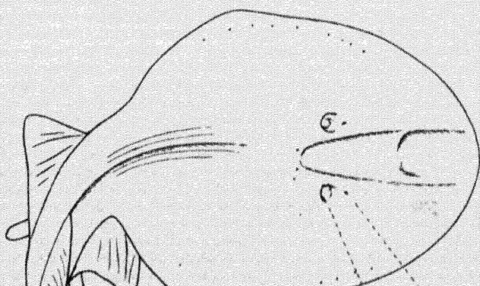


FIG. 33.—*Benthobatis moresbyi*, a blind Electric Ray from off the Travancore coast, 430 fathoms. The large pits that look like eyes are the spiracles. The dots on the edges of the disc are luminous spots (lures). Considerably reduced.

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Indian deep-sea fishes we find spiked dog-fishes and true rays (*Raia*) resembling those of temperate seas, as well as a few species belonging to the cod family, in addition to a number of characteristic abyssal forms, such as *Ophidiidæ*, *Macruridæ*, *Alepocephalidæ*, and *Halosauridæ*, as the following list shows:—

LIST OF THE FAMILIES OF INDIAN DEEP-SEA FISHES.

| | Species. | | Species. |
|---|---|---|---|
| 1. Spiny dogfishes | 2 | 14. Gobies | 4 |
| 2. Dogfishes | 3 | 15. Codfishes | 3 |
| 3. Electric rays | 1 | 16. *Ophidiidæ* | 23 |
| 4. True rays | 2 | 17. *Macruridæ* | 18 |
| 5. Sea-perches | 3 | 18. *Ateleopodidæ* | 1 |
| 6. *Scorpænidæ* | 4 | 19. Flat-fishes | 10 |
| 7. *Berycidæ* | 6 | 20. *Sternoptychidæ* | 9 |
| 8. Hair-tails | 1 | 21. *Stomiatidæ* | 5 |
| 9. Horse-mackerels | 1 | 22. *Scopelidæ* | 13 |
| 10. Dories | 1 | 23. *Alepocephalidæ* | 10 |
| 11. Weevers and Star-gazers | 4 | 24. *Halosauridæ* | 5 |
| 12. Anglers | 14 | 25. Eels | 17 |
| 13. Gurnards | 5 | 26. *Sclerodermi* | 2 |

It is not possible here to speak of all these species in detail, so I shall restrict myself to noticing briefly only those forms which clearly illustrate some of those modifications which are admittedly due to the strange conditions of life in the abysses.

We have seen that the true deep-sea fishes are, as a consequence of the enormous pressure under which they live, characterised by a peculiar delicacy and fragility of tissue. This feature is well displayed by the

spiny dogfishes (*Centrophorus Rossi* and *Centroscyllium ornatum*) and rays of our depths, also by the *Macrurida* and *Alepocephalidæ*, in all of which, when they are brought to the surface, the flesh is as brittle as tinder and the bones are quite soft and crumbly. The feature is one which can hardly be exhibited in a drawing, but the accompanying figures of *Centroscyllium ornatum* (Fig. 30) and *Macrurus investigatoris* (Fig. 31) may perhaps give a general idea of the weirdness of these denizens of the deep: they also serve to show the large eye and sombre colouring of these typical deep-swimming forms.

We have already considered the ways in which the natural darkness of the depths is lightened and obviated, so that only a minority of abyssal fishes have lost their eyesight. Of this minority, good Indian examples are *Bathypterois guentheri* (Fig. 41), *Onirodes glomerosus* (Fig. 32), and the deep-sea eels *Dysomma* and *Dysommopsis*, in all of which species the eyes are extremely small and more or less defective. In an electric Ray (*Benthobatis moresbyi*, Fig. 33) dredged in 430 fathoms off the Travancore coast, the eyes are still smaller and more rudimentary; but, curiously enough, this ray, though it must be quite blind, has a row of minute luminous glands along the edge of its disk, these probably being lures to attract prey. In *Tauredophidium hextii* (Fig. 34), dredged in the Bay of Bengal at the great depth of 1310 fathoms the

TOTALLY BLIND.

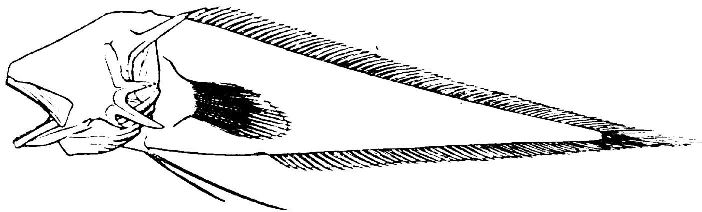

FIG. 34.—*Tauredophidium hextii*, from the Bay of Bengal, 1310 fathoms. The eyes are completely atrophied, and their sockets, which are filled with connective-tissue, are entirely hidden beneath the thick, scaly skin. The long, stout ventral fins are probably used as feelers. The huge spines of the gill-covers can be erected or depressed as required; when erected, they make a very formidable defence.

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eyes are not merely atrophied, but are entirely concealed beneath the skin and scales, so that this species, which from its enormous head and slender tail we can feel sure lives on the bottom in perpetual darkness, is blind beyond redemption: the muciferous channels of its head, whose function may probably be connected with the sense of touch, and possibly with that of hearing also, are, however, very greatly developed, and the remarkably long inner ray of the ventral fin is most likely a special feeler. *Tauredophidium* is further compensated for its helplessness in the matter of sight by having the bones of its gill-cover armed with enormous spines which must make the animal a formidable object to attack.

Good Indian examples of active deep-sea fishes which, though they may ordinarily live out of reach of the sun, do not live in absolute darkness, are the toothless perch *Brephostoma carpenteri*, a curious Berycoid (*Bathyclupea hoskynii*), and the members of the typical abyssal families *Macruridæ* and *Alepocephalidæ*, in all of which the eyes are of superlative size. The best example of all is *Leptoderma affinis* (Fig. 35), an Alepocephaloid dredged in 753 fathoms off the Kistna coast, whose eyes are like the goggles of a diver's helmet. This curious creature seems to manufacture its own light, for, though it is quite black and has no special phosphorescent glands, yet its entire skin is enveloped in a thick, opalescent epidermis, like

a luminous "bloom." The only specimen captured glimmered like a ghost as it lay dead at the bottom of a pail of turbid seawater.

A detailed discussion of the various ways in which so many fishes of the deep sea evolve light for their own use would fill a small volume.

The simplest illuminant appears to be the ordinary mucus or slime secreted by the lateral line of the body, and by the numerous channels that traverse the bones of the head and gill-covers. Even in the case of ordinary shore-fishes this slime seems at times to be phosphorescent, as any one must have noticed who has been out fishing at night. But in all the true fishes of the nether ocean, such as the *Berycidæ*, *Macruridæ*, and *Ophidiidæ*, the muciferous canals are of very singularly large size and are particularly numerous. In *Glyptophidium* (Fig. 36), which is here selected to illustrate this fact, the slime-canals of the head are so capacious that the bony ridges which form their boundaries stand out like the frills of a ruff, when the thin skin that roofs them over is removed.

At the other end of the series we find many abyssal fishes provided with highly-finished lantern-like organs, consisting of—(1) a gland, which, like those of the firefly, secretes a slowly-oxidising phosphorescent grease; (2) a silvery reflector, to intensify the light; and (3) a black, absorbent screen, to prevent diffusion,

## PHOSPHORESCENT FISHES.

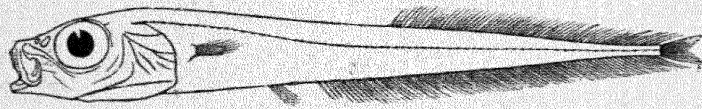

FIG. 35.—*Leptoderma affinis*, from 753 fathoms, off the Kistna coast: a luminous fish whose phosphorescence is of moderate power, and probably independent of the nervous system; half the natural size.

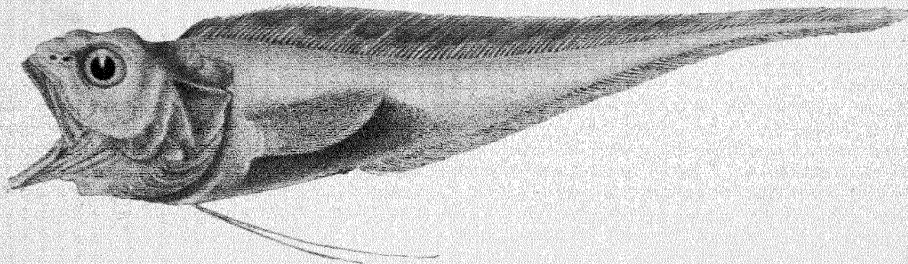

FIG. 36.—*Glyptophidium macropus*, from the Bay of Bengal, 145-250 fathoms: a fish with cavernous slime-canals on the head, whose slime is probably phosphorescent.

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the whole structure being nourished by special blood-vessels, and being brought under the owner's control by special nerves. These light-giving organs are not always so complicated as this; but whatever their form, they are all regarded as modifications of structures found in ordinary fishes, the phosphorescent glands being modified slime-glands, and the reflector and light-proof screen being modified portions of the skin. In *Lamprogrammus niger* (Fig. 17) and in *Halosaurus nigerrimus* (Fig. 37), the former being an inhabitant of depths varying from 405 to 561 fathoms, the latter being found off the Maldives in 459 fathoms, the lanterns are embedded in a row of enlarged scales running along the lateral line, like a row of port-holes in a ship. In *Diplophos corythæolum* (Fig. 38), dredged in the Andaman Sea at 185 to 405 fathoms, most of them are banked in two tiers along both sides of the body, like rows of "bull's-eyes." In *Photostomias atrox* (Fig. 39), taken in the Bay of Bengal in 1310 fathoms and in the Andaman Sea in 606 fathoms, in addition to two rows of small luminous glands along the body, there is a huge out-standing phosphorescent patch on either side of the cheek. In *Leptoderma affinis* (Fig. 35), as already mentioned, the whole epidermis seems to be tranformed into a phosphorescent overcoat, and in *Aulastomomorpha phosphorops* (Fig. 40), an Alepocephaloid dredged in 1000 fathoms in the Laccadive Sea, the skin of the entire head is

of a dazzling white colour, as if it had been an enormous reflector in life. In *Aulastomomorpha* as in *Leptoderma*, the eyes are of startling size.

As an Indian instance of a deep-sea fish in which the luminous organ serves as a lure to entice prey, *Onirodes glomerosus* (Fig. 32), a purblind Angler from 1260 fathoms, may be mentioned. In this case the lantern, which is merely a glandular mass without reflector or screen, is embedded in the thickened tip of the modified fin-ray which in other Anglers is supposed to be used as a rod and line.

Besides the species here figured, a large number of luminiferous *Sternoptychidæ*, *Stomiatidæ*, and *Scopelidæ* might be mentioned, for all these families are well represented in the deep recesses of the Indian Ocean, but enough has been said to show the extent and importance of the subject, and those who desire fuller information should consult the original accounts by Dr Günther and Professors Moseley and von Lendenfeld, in vol. xxii. of the "*Challenger*" *Reports*.

GLOW-FISHES WHOSE PHOSPHORESCENCE IS PROBABLY UNDER THE DIRECT CONTROL OF THE WILL.

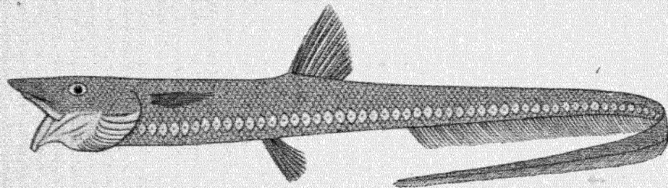

FIG. 37.—*Halosaurus nigerrimus*, from off the Maldives, 459 fathoms: a luminous fish, whose phosphorescent organs are lodged in the large scales of the lateral line; reduced.

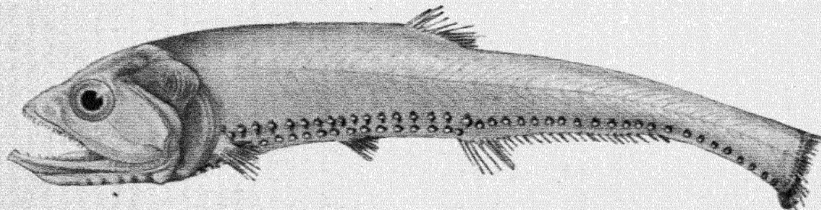

FIG. 38.—*Diplophos corythaeolum*, from the Andaman Sea, 185-405 fathoms: a fish whose luminous organs are of the "bull's-eye" type.

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# CHAPTER XVI

## THE DEEP-SEA FISHES OF THE INDIAN OCEAN

*(continued)*

In the *Investigator* collections there are several good examples of deep-sea fishes whose defective eyesight is compensated by barbels or by a wonderful transformation of fin-rays into long, streaming feelers. This phenomenon is by no means, of course, confined to the deep sea; for it is almost equally well illustrated by certain estuarine and shore fishes, such as the catfishes and *Polynemidæ*, that inhabit turbid waters full of silt, in which it is difficult to see.

Almost all the members of the Macruroid family (Fig. 31), which are characteristic denizens of the abysses, have a barbel on the chin, and in some of them several of the fin-rays are converted into streamers. *Bathypterois guentheri* (Fig. 41) is the champion of these gropers in the dark. This species has been taken near the Andamans in 490 and 561 fathoms, and in the Arabian Sea in 636 and 719 fathoms, and though it has some phosphorescent patches on the head, which may perhaps be used for alluring prey or for scaring enemies, its eyes

are of minute size; but to make up for this, seven of the rays of each pectoral fin, as well as two of each ventral and two of the caudal fin, are enormously lengthened as if to serve as feelers. A creature like this, lying with all its pectoral filaments shot forward, its long ventral feelers widely stretched out on either side, and its caudal streamers trailing far behind, would be like a spider in its web, alert on every quarter to the slightest touch from victim or foe.

*Bathypterois guentheri*, again, is one of the very few truly abyssal fishes of these seas that is not uniformly or sombrely coloured. Its head and fins are black, except the tail fin, which is white, and its body is a rich puce-brown, with two broad white cross-bands. There are thirteen other Indian species, all living in the gloomy borderland which slopes from the 100-fathom line towards the abysses, in which the body is banded after a somewhat similiar fashion. The first of these is *Chlorophthalmus corniger*, from 145-250 fathoms, belonging to the same family as *Bathypterois*, in which the body is grey, with numerous dusky cross-bands. *Scyllium quagga*, a dogfish from 102 fathoms, is striped like the animal after which it is named. In *Bembrops caudimacula* (Fig. 12), a Star-gazer living in 107-194 fathoms, the body is darkly cross-banded, and there are some small greenish "eyes" on the head. *Gobius cometes*, a goby from 89-107 fathoms, is cross-gartered in yellow, after the style of Malvolio's stockings.

TWO CRAFTY FISHES OF THE DEEP SEA.

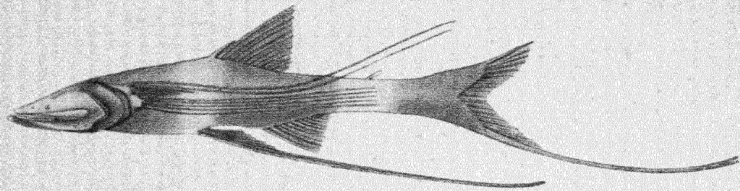

FIG. 41.—*Bathypterois guentheri*, from off the Andamans, 561 fathoms. The eyes are minute, but some of the fin-rays are produced to form far-darting feelers; reduced.

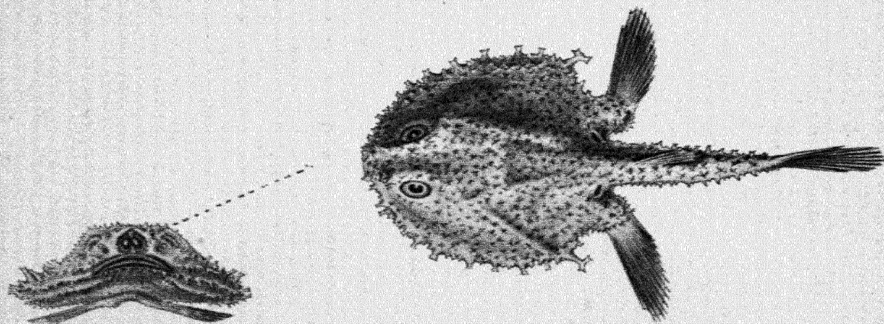

FIG. 46.—*Dibranchus nasutus*, from 188-406 fathoms; one of the deep-sea Anglers. The dotted line in the left-hand figure points to the lure.

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*Neobythites macrops*, which ranges from 188-405 fathoms, is mottled; and *Neobythites steatiticus*, a wanderer between 107 and 250 fathoms, is streaked like a fish cut in soapstone, besides having an ocellus and some stripes in its fins. In *Dicrolene nigricauda*, which is found between 188 and 284 fathoms, the body is brown, the after half of the tail is black, and the tail fin is milk-white. Finally there are no less than five kinds of soles and flounders, all lying between 100 and 400 fathoms, in these seas, in which the body is marked either with dark cross-bands or large smoky blotches.

I have already referred to the *Investigator* fishes, also dwellers in the upper parts of the abyssal slope, whose colour is either uniform rosy red, or red more or less mixed or alternated with some shade of yellow; these include several perch-like fishes and Scorpænoids, a dory, several fishing-frogs and gurnards, and one kind of codfish.

The only really splendid fishes of the deep sea with which I have a first-hand acquaintance, are a Scopeloid (*Neoscopelus*) found here in 188-405 fathoms, and a Berycoid (*Hoplostethus*); but whether their rainbow hues are natural, or are only, like those of the mackerel, the result of a last expiring ecstasy, it is impossible to say. In *Neoscopelus* the whole body is one dazzling sheen of purple and silver and burnished gold, amid which is a sparkling constellation of luminous organs. *Hoplostethus* is one glorious blaze of sunset colours, from pink to

purple, with a broad splash of bright blue on the chin and throat.

Reference has already been made to the fact that, on account of the absence of vegetation, the fishes of the deep sea are all highly carnivorous. I shall here mention a few of the Indian species that are so terribly organised in tooth and jaw and maw, as to make them the veritable scourges of the nether waters.

*Malacosteus* (Fig. 42) and *Photostomias atrox* (Fig. 39) display to perfection the nature of the mouth and teeth of these deep-sea terrors. The mouth-cleft runs right back to the enormous gill-slit, so that the face and upper jaw are joined to the skull by a mere isthmus of bone: the lower jaw is attached to the throat by nothing more than a loose thread of flesh, so that it can be made to gape like a trapdoor; and the teeth are many and sharp, and some of them are hinged fangs of enormous size. The mouth, in short, in these two creatures is like a great rat-gin spread in front of a chasm-like throat.

What the stomach of some of these deep-sea conjurors can be stretched to hold is best exhibited by *Chiasmodus niger*. This species is not shown here, because a figure of one, with its stomach distended by a fish rather more than twice its own bulk which it has swallowed, has already been published. The species has several times been taken in the North Atlantic, and once in the Bay of Bengal. Our specimen, which was slightly over six inches long, and [illegible]

DEEP-SEA FISHES WITH HEAD-LIGHTS.

FIG. 39.—*Photostomias atrox*, a highly-rapacious luminous fish from the Bay of Bengal, 1310 fathoms, whose lights are almost certainly under direct nervous control.

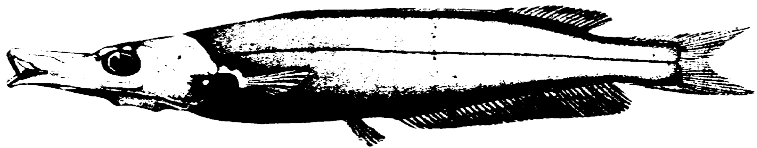

FIG. 40.—*Aulastomomorpha phosphorops*, from the Laccadive Sea, 1000 fathoms; in life the prodigiously thick skin of the head is of a dazzling white colour, and must, without doubt, be passively luminous; reduced.

[*To face page* 244.

a couple of ounces, had a belly like a balloon, and several fluid ounces of digested food were taken from its stomach. To exemplify the power of gape and swallow of a typical deep-sea fish, we may take *Odontostomus atratus* (Fig. 43), a highly rapacious Scopeloid, found in the Bay of Bengal and Andaman Sea at depths ranging from 370 to 573 fathoms, a creature whose teeth are so large as to prevent the shutting of its mouth. The specimen here figured has swallowed a cuttlefish whose breadth is much in excess of that of its own body. Other deep-sea modifications are to be noticed in its jet-black colour, and in the presence of phosphorescent pores along the course of the mucous canals of the head. *Odontostomus* is interesting in another way, since its only known congener belongs to the Mediterranean Sea. A further interest attaches to its eyes, which have an ogre-like freedom of movement, and to the orbits in which they are lodged. The eyes though lateral are capable of being turned in until they look upwards, and the orbits are converted into pockets by a transparent outer wall of skin which supports the eyeballs when they are rolled inwards.

In *Chauliodus pammelas* (Fig. 44), from 1370 fathoms off the island of Minnikoy, the teeth though not numerous are more formidable than in any other Indian fish. The figure also shows the jet-black colour, the multiple luminous organs, and the large

eye of a typical submarine rover, for there can be no doubt that *Chauliodus pammelas* is a species that lives not on the bottom but somewhere in the middle regions of the overlying canopy of water, and it is possible that, like certain other members of its own family, it may, even under cover of night, approach the surface.

*Astronesthes* (Fig. 45) is another of these black, sharp-eyed, scintillating vampires of the lower world. Its teeth are almost as cruel as those of *Chauliodus*, and its gape is only a degree less cavernous than that of *Malacosteus*. In *Astronesthes* a fleshy barbel hangs from the chin, but this is almost certainly a lure rather than a feeler, for it has a phosphorescent appearance, and in some species of the genus it is actually tipped with a phosphorescent gland like the lure of the purblind *Onirodes*.

Lures are not so common in active rapacious fishes like *Astronesthes* as they are in sluggish ground-fishes like the Anglers (*Pediculati*), who take their prey not by strength and speed but entirely by craft. On the Indian list we have fourteen species of these deep-sea fishermen, in two of which the bait is a luminous spark, while in the others it is tassel of flesh or skin that quivers cunningly. All these wily creatures are believed to lie in wait, half buried in the mud at the bottom of the sea, with their great frog-like mouths, in front of which the lure is artlessly twitching, wide

THE WAY OF A DEEP-SEA FISH.

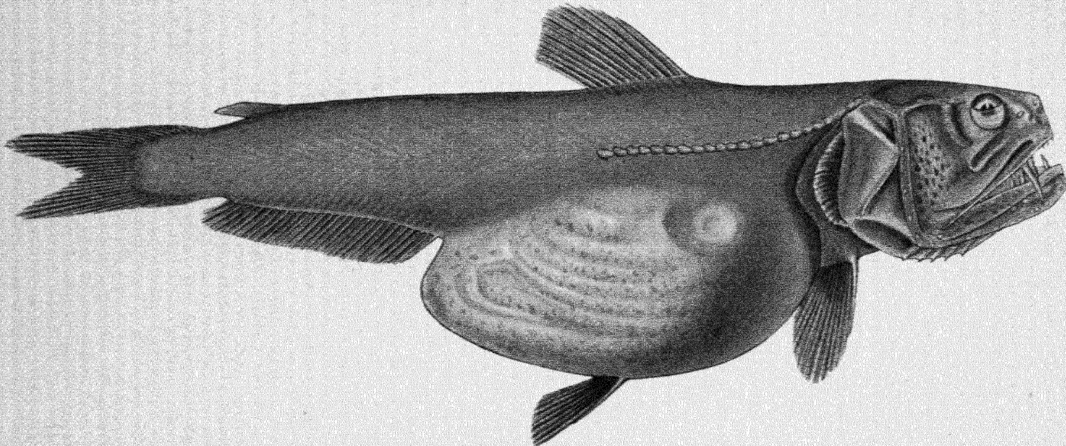

FIG. 43.—*Odontostomus atratus*, from the Bay of Bengal and Andaman Sea, 573-870 fathoms. The individual figured, which is an immature specimen enlarged, has swallowed a cuttle-fish much broader than itself; the eyes and tentacles of the cuttle-fish being visible through the distended abdominal wall of the gorger.

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open, and in this way, like the crocodile in Alice's version of the nursery hymn, to welcome little fishes in with gently smiling jaws. *Onirodes glomerosus* (Fig. 32), a denizen of the dark depths of the Bay of Bengal, is one of the Anglers that attracts its unsuspecting prey by showing a light; and *Dibranchus nasutus* (Fig. 46), from the Andaman and Arabian Seas, at depths of 188-406 fathoms, is an example of one whose bait is fleshy. Both of them are typical Anglers, and show the great unwieldly head, the large mouth, the small gill-openings, and the attenuated tail, which are the characteristic features of the family. Their whole organisation bespeaks a sedentary life; and that they cannot be active creatures that need a large amount of oxygen, is further evidenced by the degeneration of their breathing-organs, *Onirodes* having only two and a half, and *Dibranchus*, as the name implies, having only two pairs of gills.

Another Indian fish that catches its prey by stratagem is *Uranoscopus crassiceps*, one of the Star-gazers found off these coasts in 45 to 148 fathoms. Here, as in several of its well-known congeners of the shallow water, the bait, which is a protrusible tag of membrane, is attached to the very floor of the mouth, so that the welcome given to the little fishes who come to the supper of Polonius must be as easy as it is ample. What infinite entertainment this species of *Uranoscopus* must be able to provide for its too-

curious visitors is shown by the fact that seven small Scopeli, each about 1¼ inches long, were taken from the stomach of a specimen whose total length was less than 6 inches; and this specimen was a female full of roe, the capacity of whose stomach was then at a minimum.

We still know far too little about the modes of reproduction and nursery arrangements of the fishes of the nether world. In the *Investigator* we have dredged large eggs of some unknown species of ray, and these are in all respects like the "mermaids' purses" of the shores of northern seas; so that we may perhaps infer that the rays of the deep sea, like those of the shallows, deposit their eggs on the bottom or on some fixed object; but we have never discovered the developing eggs or the fry of any deep-sea Teleostean, though of many species we have dredged females in roe. On three different occasions, however, we have encountered viviparous Teleosteans, the viviparous species being *Saccogaster maculata* (Fig. 47), from 163-250 fathoms; *Diplacanthopoma rivers-andersoni*, from 947 fathoms; and *Hephthocara simum*, from 606-937 fathoms, all belonging to the one family of *Ophidiidæ*. In these three species the ovaries, which are very large, are enveloped in a tough capsule, and only those eggs which lie immediately beneath the capsule seem to give rise to embryos; and from the fact that no channels capable of carrying nutriment from the mother to the unborn young exist,

THREE SCOURGES OF THE DEEP SEA.

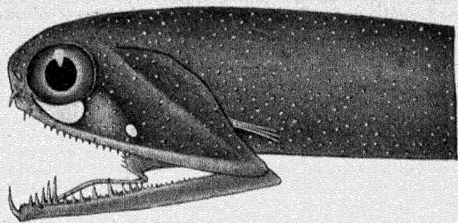

FIG. 42.—Head of a *Malacosteus*, from the Andaman Sea, 650 fathoms; showing the enormous mouth and formidable dentition, and luminous organs, large and small; enlarged.

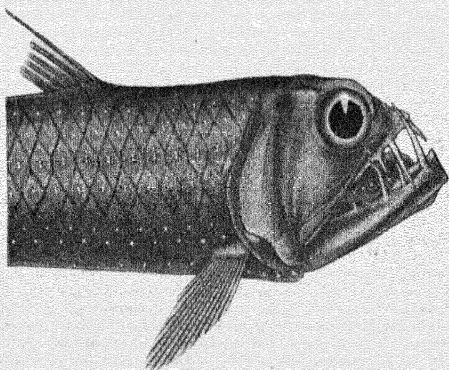

FIG. 44.—Head of *Chauliodus pammelas*, from the Laccadive Sea, 1370 fathoms; showing typical rapacious teeth.

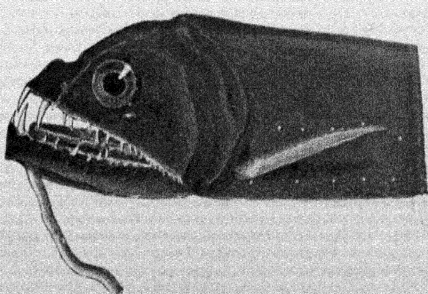

FIG. 45.—Head of an *Astronesthes*, from off the Travancore coast, 224-284 fathoms; showing raptorial dentition, and the barbel that serves as a lure.

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we may perhaps suppose that the other eggs are imbibed or in some way absorbed by the embryos in the course of their development. A male of *Saccogaster maculata* is represented in Fig. 47: it is provided with a special organ for the internal impregnation of the egg.

Although the males of the viviparous Ophidioids are distinguished from the females by a very conspicuous external character of primary importance, I cannot say that any unequivocal secondary sexual differences are discoverable among the *Investigator* deep-sea fishes, such as have been noticed in several kinds of shore fishes, with the exception, perhaps, of the single species *Neobythites*, also one of the *Ophidiidæ*. In this species, specimens of which have been dredged in the Arabian Sea in 1000 fathoms, and in the Bay of Bengal in 1310-1748 fathoms, the pectoral fin-rays of the male are about twice as long as those of the female, and some of them have the ends curiously broadened and flattened. The eyes are small, and if we may infer from this that the species lives in perpetual gloom, then we are justified in supposing that these long fin-rays of the male, which are clearly feelers, are useful sexual ancillaries of secondary importance.

Before leaving the *Investigator* fishes, attention may be bespoken for three very curious forms which have not yet been mentioned. One of these is *Halimochirurgus centriscoides* (Fig. 48) remarkable for its small mouth

placed crosswise on the upper surface—not at the extreme end—of a long tubular nozzle formed by the bones of the snout—a nozzle somewhat resembling that of the curious South American mammal, the ant-bear. This peculiar mouth and snout look as if they were meant for thrusting into worm-tubes and sucking out the contents. *Halimochirurgus*, which was dredged off Cape Comorin in 143 fathoms, is further remarkable as being one of the only two Sclerodermi—the other being *Triacanthodes ethiops* from 145-250 fathoms—that truly belong to the fauna of the deep sea.

Remarkable, not as a queer fish, but in quite another way, is *Scopelarchus guentheri* (Fig. 49), discovered off the Indus delta in 947 fathoms. This is one of those species that appeals to those who expect, when all the secrets of the depths are revealed, to be able to piece together some of the puzzles of evolution, for it is a sort of connecting-link between five or six different genera of *Scopelidæ*. In general make it strongly resembles *Scopelus*, but, as in *Paralepis*, the scales of the lateral line are enlarged: the arrangement of the fins is like that of *Chlorophthalmus*, but the eyes and teeth are in some ways suggestive of those of *Odontostomus*; finally, it possesses certain features of *Saurus* and *Saurida*. The only specimen dredged was a good deal injured by being dragged too rapidly through the water, but from the fact that the enlarged scales of the lateral line are chambered, we may perhaps infer

# SOME RARE DEEP-SEA FISHES.

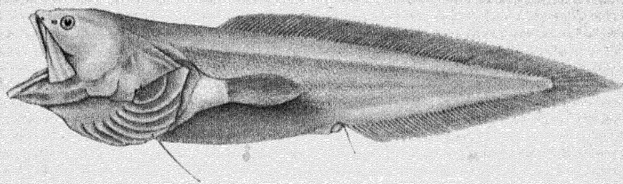

FIG. 47.—*Saccogaster maculata*, from the Bay of Bengal, 193-276 fathoms; male. The female is viviparous.

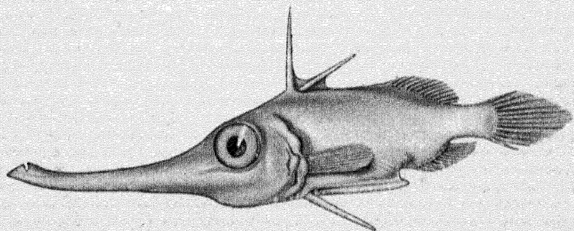

FIG. 48.—The deep-sea Snipe-fish, *Halimochirurgus centriscoides*, from off Cape Comorin, 143 fathoms; reduced.

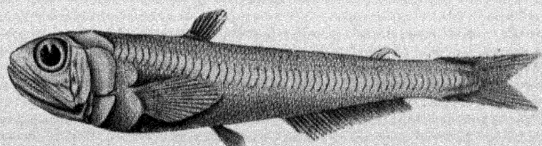

FIG. 49.—*Scopelarchus guentheri*, from the Arabian Sea, 947 fathoms; a curious generalised Scopeloid; reduced.

[*To face page* 250.

that they contained phosphorescent organs similar to those of *Halosaurus* and *Lamprogrammus*.

Another fish worthy of notice is *Ateleopus indicus*, belonging to a family that contains only one other species —*Ateleopus japonicus*, from Japan. The Indian species has been dredged in depths ranging from 188 to 405 fathoms, and from the colour and texture of its skin, as well as from its soft friable muscles and imperfectly ossified bones, we may be quite sure that it is a denizen of the depths.

In conclusion, I may mention that a final report upon the deep-sea fishes collected by the *Investigator* was issued in 1899 as an Indian Museum publication, and that the species new to science have been figured in the *Illustrations of the Zoology of the R.I.M.S. "Investigator,"* published annually since 1892, under the auspices of the Director of the Royal Indian Marine.

# CHAPTER XVII

## OF THE DEEP-SEA CRUSTACEA OF THE INDIAN OCEAN

Our general knowledge of the deep-sea Crustacea, like that of the deep-sea fishes, is one of the results of the expeditions and surveys specified in a former chapter, among which that of H.M.S. *Challenger* stands out in historic relief. Here we must restrict ourselves to a glance at a few of the species discovered by the *Investigator*, and as our view is intended for the amateur rather than for the specialist, it may, perhaps, be as well to preface it with a brief statement of the present classification of the whole group.

The class Crustacea, as now existing, is divided into two great sub-classes, the *Entomostraca* and the *Malacostraca*, with a small connecting-link between the two, represented by Nebalia (*Leptostraca*).

The *Entomostraca* include a host of marine and freshwater forms, mostly of small size, in which the segmentation of the body, when not obscured or actually obliterated by parasitism, is indefinite and inconstant. In this sub-class are comprised (1) the multisegmented *Phyllopoda*, with Branchipus as a

DEEP-SEA FEATHERS.

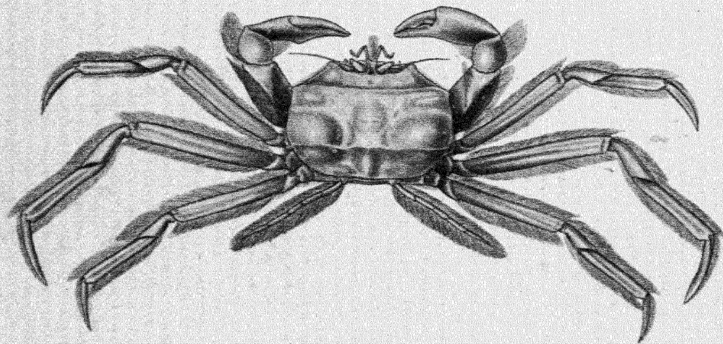

FIG. 55.—*Pteroplax notopus*, the Flat-backed Feather-crab, from the Bay of Bengal, 100-250 fathoms. The eyes are almost rudimentary, probably as a consequence of living in deep and turbid water. The legs, especially the small and modified fifth pair, are feathered, perhaps for swimming, but probably for supporting the animal on a soft, yielding, muddy bottom.

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type, of which the majority live in fresh water, though some, such as the curious Apus, are found in brine-pools; (2) the *Cladocera*, or water-fleas, most of which occur in fresh water and are partly enclosed in a bivalve shell of their own; (3) the marine and fresh-water *Ostracoda*, in which the entire head and body are concealed by a bivalve shell; (4) the *Copepoda*, most of which are marine, and many parasitic on fishes; and (5) the *Cirripedia*, or barnacles, with which every one is familiar. Only a small number of Entomostraca are comprised in the true abyssal fauna.

The sub-class *Malacostraca* contains all the large and highly-organised Crustacea, whose body is as a rule built up of twenty-one segments, each of which usually carries a pair of multipartite appendages. In this sub-class are grouped (1) the marine and lacustrine *Amphipoda*, of which the common "sand-hopper" is a familiar example; (2) the *Isopoda*—exemplified by the common "wood-louse" and "slater"—which are found in the sea and in fresh water as well as on land; (3) the marine *Stomapoda* or locust-shrimps, whose eyes are borne on stalks; (4) the sessile-eyed *Cumacea*, which resemble the larvæ of prawns, and live in the sea; (5) the marine stalk-eyed *Schizopoda*, or opossum-shrimps; and (6) the *Decapoda*, a great Order of stalk-eyed forms, widely distributed through all seas and fresh waters, as well as on land, and comprising all the crustaceans that we use as food.

As our story refers chiefly to the *Decapoda*, it may not be amiss to give an orderly epitome of the groups that compose this, the highest order of the crustacean class.

Most monographers agree in dividing the Decapoda, according to the size and finish of the abdomen or "tail," into three sub-orders, namely (1) the *Macrura* (prawns and lobsters), in which the "tail" is at least as long as the cephalothorax, and ends in a large tail-fan for swimming; (2) the *Anomala* (hermit-crabs), whose abdomen, though it almost always ends in a tail-fan of reduced proportions, is either bent or coiled so as to be useless for swimming; and (3) the *Brachyura* (crabs), whose abdomen is tucked up under the cephalothorax and never ends in a tail-fan.

The *Macrura*, which are the most primitive of the Decapoda, are again split into two groups, namely (1) the *Caridides* (prawns and shrimps), in which a leaf-like scale of very large dimensions is attached to, and can completely conceal, the peduncle of the second pair of antennæ; and (2) the *Astacides* (lobsters, crayfishes, and scorpion - lobsters), whose antennal scale, when present, is not large enough to entirely cover the antennal stalk. Of the Caridides, three sub-groups are recognised, namely (1) the *Peneidea* (prawns), whose third pair of thoracic legs end in nippers, but are not enlarged; (2) the *Stenopidea* (sponge- and zoophyte-haunting prawns) in

which these legs are not only chelate, but are monstrously enlarged; and (3) the *Caridea* (shrimps), which never have these legs (third pair) chelate.

The *Anomala*, in whom the antennal scale, if present at all, is a mere spine, are more highly organised than the Macrura. Some of them have an almost misleading resemblance to crabs, but even the most crab-like of them (such as *Lithodes* and *Paralomis*) are slightly lop-sided, and never have the partition or *septum* between the first pair of antennæ, which is diagnostic of the Brachyura. Others of them have a strong resemblance to certain kinds of lobsters, but these can always be distinguished, even from those Macrura which have no antennal scale, by the facts that the abdomen is folded beneath the cephalothorax, and the last pair of thoracic legs are rudimentary. We recognise three brigades of the Anomala, namely the aberrant *Hippides*, or mole-crabs, which burrow in the sand; the *Pagurides*, or true hermit-crabs, most of which, though by no means all, live in a cast-off mollusk shell; and the *Galatheides*, which look something like small lobsters, but are sedentary, and so have the abdomen permanently bent.

The *Brachyura*, or crabs, are the highest of all the Crustacea, as is shown by the concentration of the segments and consequent centralisation of the nervous system, and by the more perfect specialisation of the

appendages. Three great groups of Brachyura have been established, namely the *Dromides*, or primitive crabs, in which the abdomen is still large, and the eyes and first pair of antennæ are either unprotected or else fold into common pits; the *Oxystoma*, in which the mouth is produced acutely in the middle line; and the *Brachyura vera*, whose mouth is cut square, whose abdomen—especially in the male—is small, and whose eyes and first pair of antennæ are almost always retractile into well-defined sockets of their own.

Before the launch of the *Investigator*, in 1881, practically nothing was known of the Crustacea that live in the depths of the seas of British India, though the late Professor Wood-Mason, when dredging in deep water off the Andamans in the year 1873, had indeed discovered an interesting blind lobster, which he named *Nephropsis*. Since then, as the result of the *Investigator's* activity, about 275 species have been captured between the meridians of 65° E. and 99° E. in the nether waters, from 100 to 2000 fathoms deep.

As in the case of the fishes, these crustacean denizens of the cold and gloomy depths are, as a whole, considerably different from those of the shore in the same latitudes, and include, besides many characteristic bathybial species, a number of forms allied to the littoral species of the temperate zones.

CARPENTER'S BLIND LOBSTER.

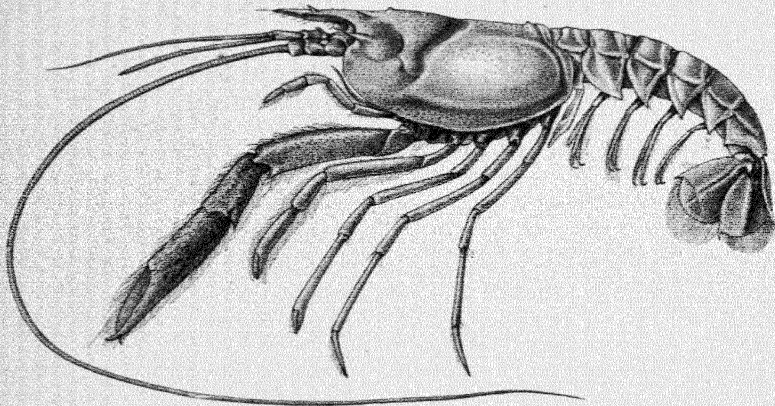

FIG. 59.—*Nephropsis carpenteri*, from the Bay of Bengal, 193 fathoms. The eyes have almost disappeared, but the eyestalks remain. The outer or olfactory branch of the first pair of antennæ is considerably thickened, probably as a compensation for the loss of sight. The figure represents a male.

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such as crabs of the typical northern genera *Homola*, *Latreillia*, and *Maia*, and characteristic northern shrimps like *Crangon*, *Pandalus*, and *Pasiphæa*.

So far as they have been named, the *Investigator* deep-sea species belong to the following groups:—

| | Species. | | Species. |
|---|---|---|---|
| 1. *Cirripedia* (barnacles) | 2 | 9. *Astacidea* (lobsters) | 10 |
| 2. *Amphipoda* (sand-hoppers) | 4 | 10. *Thalassinidea* (scorpion-lobsters) | 10 |
| 3. *Isopoda* (sow-bugs) | 2 | 11. *Paguridea* (hermit-crabs) | 13 |
| 4. *Stomapoda* (locust-shrimps) | 3 | 12. *Galatheidea* (hermit- or coral- lobsters) | 39 |
| 5. *Schizopoda* (pouch-bearing shrimps) | 9 | 13. *Dromides* (sponge-crabs) | 9 |
| 6. *Peneidea* (prawns) | 27 | 14. Oxystome crabs | 16 |
| 7. *Caridea* (shrimps) | 58 | 15. True crabs | 28 |
| 8. *Stenopidea* (sponge-prawns) | 3 | | |

Just as with the fishes, the higher Crustacea of the deep sea, though they do not include, as it was at one time expected that they would, any abiding relics of long-past geological ages, yet as a whole form a slightly more antiquated assemblage than those of the shore. This is specially noticeable in the case of the highest order *Decapoda*, in which group we still find survivors of the elsewhere-extinct Triassic family *Eryonidæ*, and a remarkable exuberance of such archaic and primitive stocks as the *Peneidea* and *Caridea*, along with a suggestive paucity of the highest and most recently evolved tribes of crabs.

In the following paragraphs we shall consider some of the ways in which the Crustacea of the nether

waters have been modified to meet the peculiar circumstances—depending on increased pressure, darkness, persistent low temperature, and deficiency of oxygen—of their own world, using Indian species to illustrate the argument.

First, as regards persistent cold: in the seas of India the winter temperature of the surface water is from 80° to 85° Fahr., while at a depth of 100 fathoms it is only about 60° Fahr., and at 1000 fathoms it is less than 40° Fahr., whence it follows that, were temperature the only consideration, forms that live in high northern seas could exist equally well in the cool depths of the tropics. Of course the matter is not nearly so simple as this, yet—as revealing tendencies—we do find in these depths a fair number of crustaceans that, until recently, have been regarded as characteristic of northern temperate seas: such are the crabs *Maia*, *Scyramathia*, *Latreillia*, and *Homola*, all of which are found within Indian limits at 50-500 fathoms; the lobster *Nephrops andamanica*, found here at 150-400 fathoms, which differs only very slightly from the Norway lobster (*Nephrops norvegica*); and the shrimps *Pasiphæa* and *Crangon* (*Aegeon*) and *Pandalus*, which are not uncommon here at similar depths. Again, the order *Schizopoda*, which is almost hyperborean in its proclivities, is represented in Indian latitudes, at depths of 500-1750 fathoms by no less than nine species.

DEEP-SEA HERMIT-LOBSTERS, WITH DULL, LACK-LUSTRE EYES.

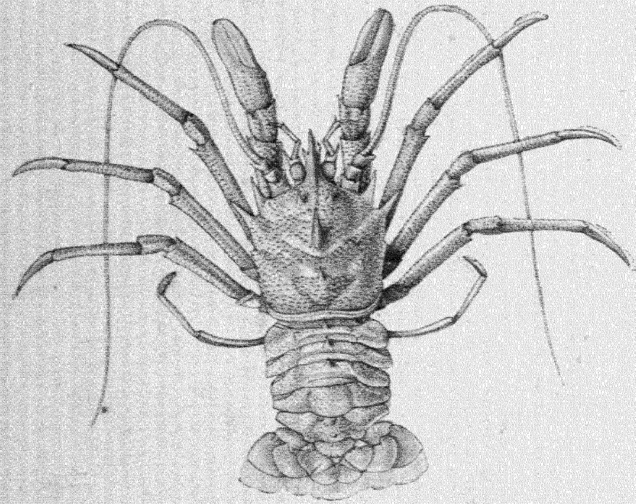

FIG. 57.—*Galacantha investigatoris*, from off Minnikoy, 1200 fathoms. The position is quite conventional.

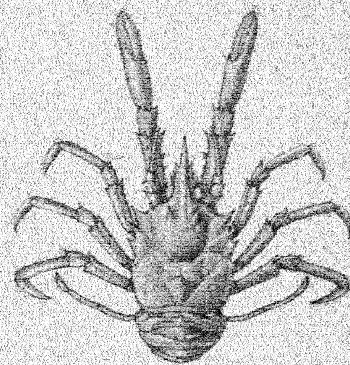

FIG. 58.—*Munidopsis triæna*, from off the Andamans, 375 fathoms. The figure represents a natural posture, except that the small fifth pair of legs should be tucked up out of sight.

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The effects of living under a pressure that may amount to anything between 300 lbs. and 3 tons upon the square inch are not so astonishing as might be expected. The tissues of Crustacea like *Pentacheles* (Fig. 60), which undoubtedly live on the bottom and at the greatest depths, are certainly delicate, but not more so than those of many oceanic species that live near the surface, such as *Sergestes.* On the other hand, there are few crustaceans that have a thicker and harder "shell" (cuticular skeleton) than *Glyphocrangon* (Fig. 52), *Munidopsis* (Fig. 58), and *Galacantha* (Fig. 57), all of which assuredly are ground-dwellers in abyssal depths; and there are many other forms, such as *Dorodotes*, *Psalidopus* (Fig. 21), and *Nephropsis* (Fig. 59), in which the exoskeleton is at least as hard as that of their relatives of the shallows.

Absence of sunlight affects Crustacea in the same diverse ways—depending upon the original nature and plasticity of the living material operated upon—that it affects fishes, in some cases putting a premium upon phosphorescence and owlish eyes, in other cases leading to degeneration or complete atrophy of the organs of vision.

Of the phosphorescent Crustacea of the deep sea, the most brilliant observed in the *Investigator* are *Heterocarpus alphonsi* (Fig. 15), from 480-750 fathoms, and *Aristaeus coruscans* (Fig. 16), from 561-824 fathoms,

in both of which species floods of pale lambent light have been seen to gush from, as near as could be judged, the openings of the organs that correspond with the kidneys of higher animals. In both these species the eyes are large and intensely black. Other species in which the eyes are remarkable for their large size and depth of colour are the Andaman lobster (*Nephrops andamanica*), from 150-400 fathoms, the blanket-crab, *Chlænopagurus andersoni* (Fig. 2), from 102 fathoms, the stopper-fisted hermit-crab, *Pylocheles miersii* (Fig. 65), from 185 fathoms, and the squeaker-crab, *Psopheticus stridulans* (Fig. 50), from 170-420 fathoms: all of these, it is to be observed, are inhabitants of the upper parts of the abyssal slope, which, though gloomy, is not absolutely dark; and I think our facts are sufficient to justify the statement that most of the Crustacea of this zone which do not burrow, will be found to have large and deeply-coloured organs of vision. This probably explains the largeness of the eyes in the species of *Munida* (Fig. 51) which are so common on coral ground in depths ranging from 150 to 400 fathoms. The species figured is the common *Munida andamanica*, which, however, the artist has drawn in a conventional attitude, with the abdomen fully extended; in life the after half of the tail is folded, as is shown in the figure of *Munidopsis triana* (Fig. 58). There are, on the other hand, certain ground-loving species of the sunless abysses,

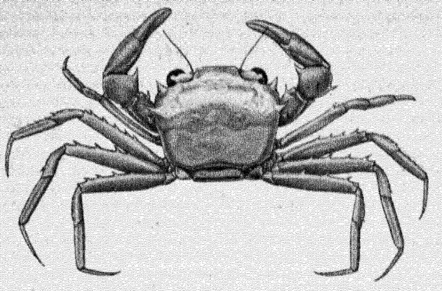

FIG. 50.—The Squeaker Crab (*Psopheticus stridulans*), from the Andaman Sea, 173-419 fathoms. A dismal sound, like the squeaking of a pencil on a slate, can be made by rubbing the spine on the "arm" of this crab against a roughened knob on the adjacent orbit; reduced.

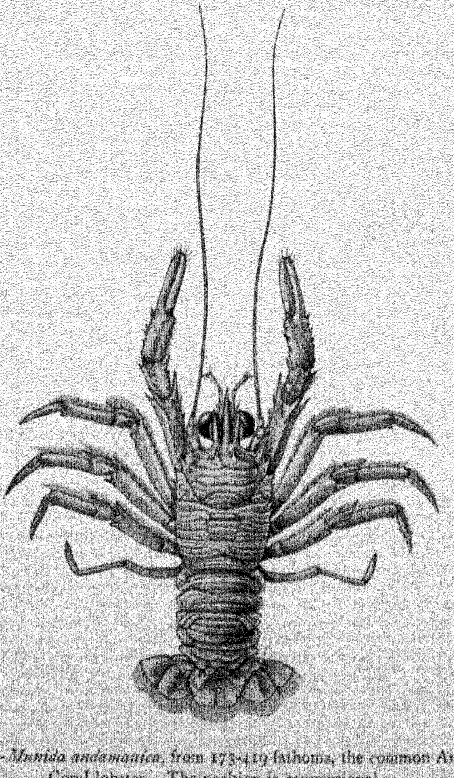

FIG. 51.—*Munida andamanica*, from 173-419 fathoms, the common Andaman Coral-lobster. The position is conventional.

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DEEP-SEA CRUSTACEA WITH ABNORMALLY LARGE EYES.

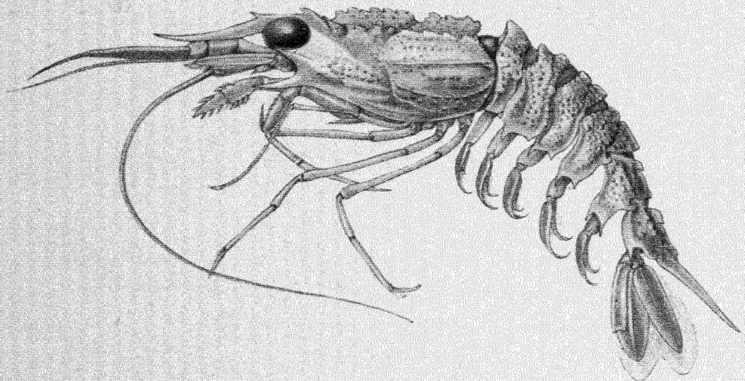

FIG. 52 —*Glyphocrangon priononota*, from 865-1022 fathoms; male; showing the huge eyes and the remarkably enlarged olfactory branch of the first pair of antennæ. Observe also the locking-joints of the hinder segments of the tail, and the bayonet-like telson.

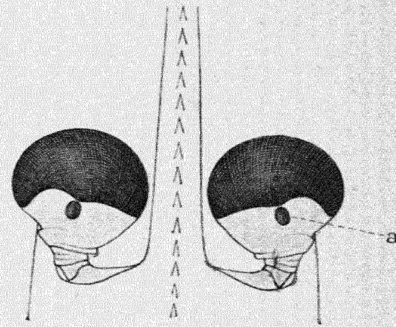


FIG. 53.—Eyes and accessory eyes (*a*) of *Parapandalus spinipes*, an Indian deep-sea shrimp; enlarged.

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such as most of the Glyphocrangons (Fig. 52), in which the eyes are of good colour and of singular bigness: here, as daylight is entirely excluded, we may, perhaps, trace the influence of phosphorescence.

In a good many of the large-eyed deep-sea shrimps (*Caridea*), and in a few of the prawns (*Peneidea*) small accessory eyes are present, either on the eye-stalk itself or at the end of a small branch of the eye-stalk. The figure of *Parapandalus spinipes* (Fig. 53) shows a pair of these accessory eyes, which, it should be mentioned, some authorities are inclined to regard as phosphorescent organs.

If it be true that the active inhabitants of the dim twilight of the upper part of the abyssal slope are usually characterised by eyes of owl-like magnitude, yet when we are dealing with sedentary or burrowing species, or even with many active species that we feel sure must live far down in the abyss, it is usual to find that the eyes are small or in some way imperfect. For instance, in the oceanic shrimps of the family *Pandalidæ*, which are often taken in less than 200 fathoms water, the eyes as a rule are large, and accessory eyes are common; but *Dorodotes reflexus*, a member of this family, which, from its colour and from the density of its exoskeleton as well as from the fact that during all these years it has never yet been captured unless the dredge has gone below 1000 fathoms, we have good reason to regard as a true denizen of the deep sea, has particularly small

eyes. Similarly with the *Hoplophoridæ*, another family of oceanic shrimps: the only Indian species whose eyes are small and defective is *Acanthephyra microphthalmus*, and this is a species which dredging after dredging, and year after year, we never see unless the dredge is let down into the actual shades below 1500 fathoms. On the other hand, most of the abyssal hermit-crabs have quite perfect, though small, eyes: such is the case with *Parapagurus pilosimanus* (Fig. 67), a creature that we know must crawl about on the bottom, but which we have brought up from a depth of 1997 fathoms, where there can be no trace of daylight. We must remember, however, that a great many hermit-crabs live in partnership with zoophytes, and that many zoophytes have the power of emitting bright flashes of light. *Parapylocheles scorpio* (Fig. 54), from 405 fathoms, is singular in having minute and pale eyes; but as this species is quite symmetrical, it evidently does not live in a spiral shell encrusted with zoophytes, but is probably a burrower, in which case its defects of eye are accounted for. The feather-crab, *Ptenoplax notopus* (Fig. 55), though it lives at a depth of only 100-250 fathoms, where daylight should not be entirely obscured, has very minute eyes, instead of the staring organs that we should expect: it evidently is not a burrower, for its legs seem to be specially modified to keep it from sinking into mud, so that we must propose some

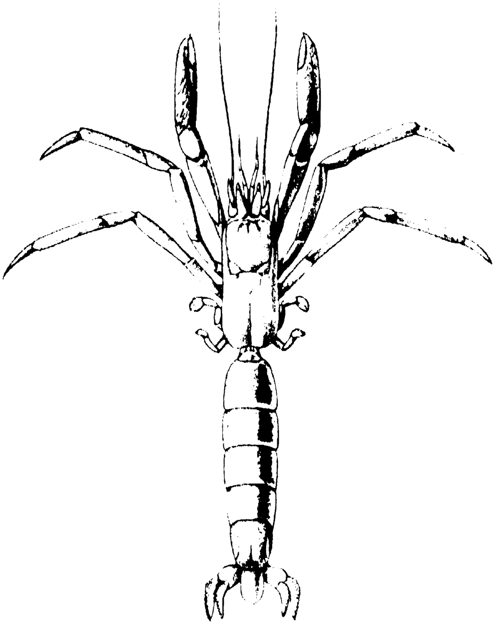

FIG. 54.—*Parapylocheles scorpio*, from the Andaman Sea, 405 fathoms. This Hermit-crab is remarkable in being quite straight and symmetrical. Its eyes are pale and minute, probably as a consequence of living in deep water and burrowing in the mud.

FIG. 56.—*Plastocrangon cæca*, from the Bay of Bengal, 561 fathoms; a deep-sea shrimp, with pale, dull eyes, which are probably useless for vision. The figure shows the large eggs of this and kindred shrimps; also the locking-joints of the hinder abdominal segments, and the bayonet-shaped telson in a posture of defence.

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other explanation for the degeneration of its eyes. The explanation is, I think, found in the fact that it lives only in very muddy water, that is to say, in darkness after all.

Eyes of fair size, but deficient in colour and without facets, are very frequently met with among the sedentary Crustacea of the profundities of the ocean. Of the 241 species of *Malacostraca* dredged by the *Investigator* in the depths, more than 20 per cent. show this characteristic form of degeneration. For instance, in *Plastocrangon cæca*, from 561 fathoms (Fig. 56), the eyes are quite distinguishable, but instead of being faceted they have a smooth, dead surface, and their colour is a pale chalky yellow. The same pallid, milky-yellow, lack-lustre eyes, which, though they may perhaps serve to distinguish between light and darkness, can never form a definite visual image, characterise the species of *Galacantha* (Fig. 57) and the innumerable species of *Munidopsis* (Fig. 58), which are found nowhere but in the sullen bottoms of the deep. Unhappily, eyes of this sort cannot be properly portrayed in uncoloured figures. With respect to these figures, it should be observed that *Munidopsis* (Fig. 58) is drawn in the natural position with the after half of the tail folded, while *Galacantha* (Fig. 57) has been placed in a conventional attitude which it does not adopt in life.

In *Nephropsis* (Fig. 59), which in all probability

is a burrowing crustacean, degeneration has gone one stage further. Here the eyes are barely distinguishable from the short and slender eye-stalks, and may truly be said to be useless rudiments. Forlorn eye-stalks of the same kind are all that remain to *Phoberus cæcus*, a large spiny lobster, from 500-1000 fathoms, and to the scissor-foot prawn *Psalidopus* (Fig. 21), from 400-600 fathoms, as well as to certain deep-sea crabs that might be mentioned. The figure of *Nephropsis* (Fig. 59), which represents a male, shows the thickened outer or olfactory branch of the first pair of antennæ, the greater development of the organ of smell being probably a compensation for defective eyesight.

The final stage of degeneration, in which the eyes have altogether disappeared, leaving only the bare ruins of an eye-stalk behind them, is well illustrated by the blind shrimp, *Prionocrangon ommatosteres* (Fig. 20), whose eye-stalks are represented by a pair of useless scales. Similiar useless but eloquent eye-stalks are to be seen in a blind scorpion-lobster (*Callianassa cæcigena*), from 200-350 fathoms, and in a blind Schizopod (*Petalophthalmus armiger*), from 902 fathoms. In all the recent *Eryonidæ*, too, of which *Pentacheles hextii* (Fig. 60), from 188-719 fathoms, is a good example, the eye-stalks, bereft of eyes, are firmly adherent to the carapace, a condition which is the next stage to complete disappearance.

HEXT'S FLAT-BACKED LOBSTER.

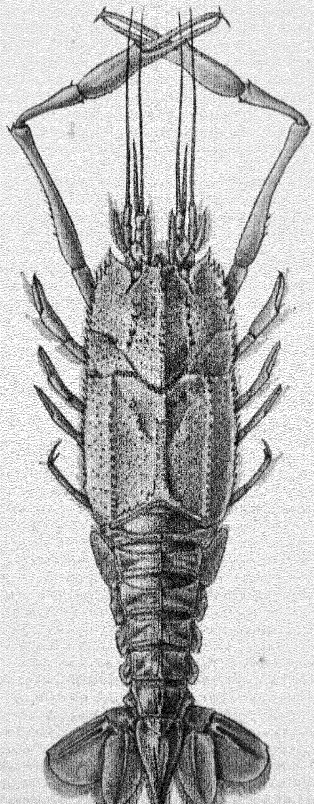

FIG. 60.—*Pentacheles hextii*, from 188-719 fathoms. The eyes have disappeared, the eyestalks are adherent to the carapace, and the sockets are closing up.

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# CHAPTER XVIII

## THE DEEP-SEA CRUSTACEA OF THE INDIAN OCEAN
## (*continued*)

As might be expected, arrangements which appear to be meant to counteract obscurity of light and defects of vision are to be found among the Crustacea of the deep sea. Quite a number of blind and purblind species, or of species living in darkness, can be named whose sense of smell, as evidenced by a remarkable thickening of the outer or olfactory lash of the first pair of antennæ, must be much above the average. This enlargement of the olfactory organ is seen in *Nephropsis carpenteri* (Fig. 59): it is even better marked in *Pentacheles hextii* (Fig. 60), and *Plastocrangon cæca* (Fig. 56), and best of all in *Glyphocrangon priononota* (Fig. 52). In *Pentacheles*, too, the basal joint of the same pair of antennæ, in which joint the organ of hearing is lodged, is very suggestively increased in size, as it also is in the blind *Prionocrangon ommatosteres* (Fig. 20).

The influence of darkness on the colouring of the deep-sea Crustacea is as well marked as it is on that

of the deep-sea fishes. Their colours are not dull or obscure, indeed they are usually very vivid; but they are uniformly laid on, and there is the same paucity of spots and stripes and variegated patterns. Of the Indian species whose living colours have been noted, 27 per cent. are some decided shade of red, 22 per cent. are some shade of pink, and 22 per cent. are orange or yellow; a few are brown, a few purple, a few are cream-coloured or grey, and a few quite white; but in only 17 per cent. can any sort of spots or stripes be made out, and even then the patterns are very simple ones, composed of red and white, or orange and white, or red and orange. Never do we see those freaks of colour, or those labyrinthine mottlings and dapplings, that excite our curiosity when handling the crabs and shrimps of the reefs, and this, I think, is a fact which has not always been adequately considered in our endless discussions on warning and protective colouration. In several cases where the adult is red or orange, the unhatched young are blue or peagreen, which seems to show that the red and the orange uniforms of the nether waters have been brought about, probably by natural selection, since the exodus into the abysses, and must therefore be of some service.

That at certain depths below the surface there must be some peculiarity about the supply of oxygen is indicated by the facts that in many of the deep-sea

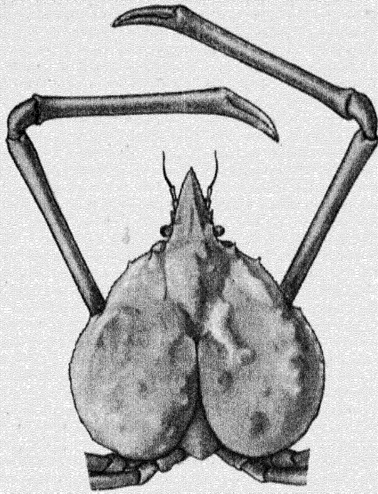

FIG. 61. — *Encephaloides armstrongi*, Armstrong's Spider-crab, showing the swollen cavernous gill-chambers. The four pairs of crawling legs are too long to be shown. This crab is one of the characteristic inhabitants of the 100-fathom line in Indian Seas.

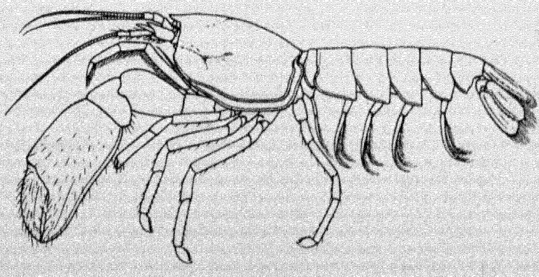

FIG. 66.—*Iconaxiopsis andamanensis*, from the Andaman Sea, 238-290 fathoms; enlarged twice. This small Scorpion-lobster differs very little from *Iconaxiopsis laccadivensis*, which shelters itself in the branches of deep-sea zoophytes. The exact habits of *Iconaxiopsis andamanensis* are not known.

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Crustacea the gill-plumes are large and lax, the gill-chambers swollen, and the openings leading to and from the gill-chambers singularly patulous. These modifications are most apparent in the active prawns and crabs which live near the 100-fathom line: *Encephaloides armstrongi* (Fig. 61), a spider-crab found on the edge of the abyssal slope all round the coasts of India, exhibits them in an extreme degree, and in this species the enormous gill-chambers rise up until they meet across the middle line of the carapace, but without any fusion of their walls. Such a remarkable increase in the breathing capacity appears to point, like the chest-expansion of mountaineers, to difficulties of respiration of some kind to be surmounted.

Although the conditions of life in the depths might seem to be reduced to a minimum of simplicity, yet evidences are not wanting that, among the higher Crustacea there, they are complicated, much as they are everywhere else, by the play of the sexual instincts.

It is written that the male must exert himself to find a mate, and where sight cannot help him in his search a kind of blind-man's buff is the only alternative. In this serious game many deep-sea Crustacea especially those of the shrimp tribes (*Caridea*), trust to the sense of smell, as the greatly-developed outer or olfactory branch of the first pair of antennæ bears witness. These antennæ, again, seem to be used by

the males of some species for catching their partners, and in *Parapeneus rectacutus* (Fig. 62) we see how they are turned into a sort of crook for this purpose. This has long been thought to be their function in the prawns of the oceanic genus *Sergestes*. In the males of certain other deep-sea prawns the third pair of foot-jaws are modified in a way which can only mean that they are used for hooking on to a partner of the opposite sex: foot-jaws of this strange kind are best seen in *Aristæus crassipes* (Fig. 63).

In those deep-sea forms whose nippers are greatly enlarged, these of course will be used, as they are by many shore-crabs, for the subjugation of rivals, and for the compulsion of the female. In no case is this better illustrated than it is by the deep-sea hermit-lobsters of the genus *Munida*, in many species of which the great chelipeds—one or both—of the adult male are more curiously and vastly more strongly fashioned than those of the female and young unseasoned male.

There are some deep-sea prawns of the genus *Aristæus* in which the antennal scale of the male alone is curiously lengthened and thickened, but for what particular purpose we cannot say, though Spence Bate considered that it is a prehensile apparatus. *Aristæus edwardsianus*, Johnson, an Atlantic species which is also common in Indian waters, furnishes the best example of this.

BEAK AND CLAW IN THE DEEP SEA.

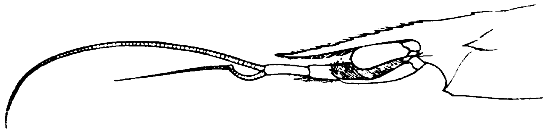
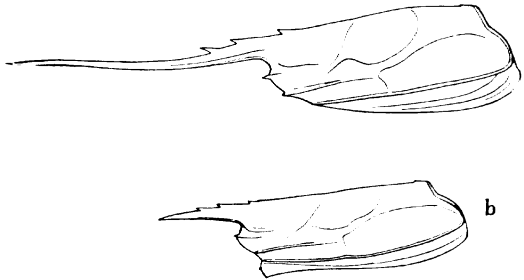


FIG. 62.—First pair of antennæ of the male of the deep-sea Prawn, *Parapeneus rectacutus*, showing the prehensile crook of the outer lash.



a

b

FIG. 64.—Carapace of the deep-sea Prawn. *Aristæus crassipes*, showing the difference between the sexes—(*a*) female, with long, bayonet-like rostrum; (*b*) male, with short rostrum.

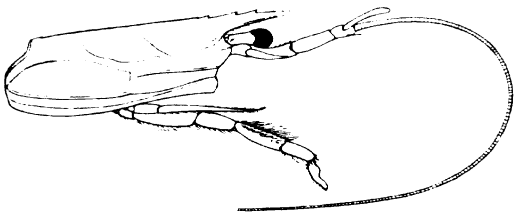


FIG. 63.—Male of *Aristæus crassipes*, a deep-sea Prawn, showing the hook-like end-joint of the outer jaw-feet.

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There is a still larger number of deep-sea prawns of this genus *Aristæus* in which the rostrum of the female is very much larger than that of the male. Now the rostrum is generally regarded as the most formidable weapon of offence that a prawn possesses, so that where it presents any sexual differences at all, we should expect it to be largest in the male, which, as a rule, is the more emulous and more pugnacious sex. Where, however, as in so many species of *Aristæus*, we find that it is largest in the female, we are inclined to suspect that the character of the sexes is reversed, and that instead of the males tilting for the favours of the females, the latter fight with each other over the males; this suspicion is strengthened by the facts that, in the species we are considering, the females are far larger and more numerous than the males, so that the latter puny sex must be at a great premium. This difference between the two sexes is perhaps better marked in *Aristæus crassipes* (Fig. 64) than in any other Indian species.

An interesting fact, which throws some light upon the exigencies of life in the depths, is that many of the deep-sea Crustacea lay eggs of relatively enormous size, of which, of course, only a few can be produced at each brood. This points to the conclusion that the young are hatched in the likeness of their parents, and not, as in the case of most shore-crustaceans, as minute larvæ which only reach the adult form after a prolonged

series of metamorphoses. It also shows us that the preservation of many of the deep-sea species is best assured, not by the irresponsible scattering abroad of a vast multitude of larvæ, but by protracted parental attention to a limited number of offspring. This indeed is an inference which we might have gleaned from our study of the Teleostean fishes of the deep sea, many of which have very large eggs, and several of which are viviparous. Among the sedentary deep-sea Crustacea large eggs are characteristic of the extensive genera *Munidopsis* and *Glyphocrangon*. The figure of *Plastocrangon cæca* (Fig. 56) shows examples of these large eggs, attached, in the usual place, to the swimming legs of the mother. Numerous active species also produce large eggs, the largest of all being credited to *Psathyrocaris platyophthalmus*, a little creature which, though not much more than 3½ inches in length, lays eggs nearly quarter of an inch long. On the other hand, most of the active deep-sea Crustacea, which swim in the canopy of the waters—such as *Acanthephyra*, *Nematocarcinus*, and the *Pandalidæ* (*Dorodotes* excepted)—and even some such undoubted abyssal forms as *Polycheles* and *Pentacheles* lay a multitude of small eggs, as also do most but not all of the deep-sea crabs. *Dorodotes reflexus* is singular in producing, at one brood, eggs of two kinds, namely, large eggs which give rise to young, and small eggs whose *rôle* is not known, unless they are to

be regarded as a store of food for the young when hatched.

I may conclude these remarks upon the Indian deep-sea Crustacea with a few *mirabilia*, taken in order.

The great, heavy Isopod, *Bathynomus giganteus*, which is found only here and in the depths of the Gulf of Mexico, has already been mentioned; a specimen recently dredged off the north-east coast of Ceylon, in 594 fathoms, is a foot long, and thick and broad in proportion; compared with other Isopodes, it is a Brobdingnagian among Gullivers.

The *Amphipoda* of the deep sea also run to a large size. The most massive species taken by the *Investigator* is *Andania spinescens*, a blind species 1½ inches long, dredged in the Bay of Bengal at the enormous depth of 1997 fathoms. Two specimens of *Cystisoma spinosum*, taken in the Andaman Sea between 172 and 498 fathoms, are much bigger than this, but what they gain in inches they lack in substance, for they are mere ghosts of creatures, as transparent and almost as fragile as a jellyfish; indeed, it is probable that, like most jellyfish, they do not belong to the deep-sea fauna, but float about on the face of the waters.

The deep-sea *Schizopoda* are also vastly larger than their exiguous kindred of the sea surface. The largest species dredged by the *Investigator*, a blood-red *Gnathophausia*, is about 3½ inches long; but specimens

nearly double this size have been obtained in other parts of the world.

Among curiosities made use of as tenements by certain deep-sea Crustacea whose choice is, perhaps, rather more limited than that of their relatives near shore, one of the most remarkable is the habitation of *Pylocheles miersii* (Fig. 65), a hermit-crab found by Dr A. R. S. Anderson in 185 fathoms. This singular hermit-crab, whose body is as faultlessly symmetrical as that of any lobster, lives in hollow twigs of bamboo and mangrove which have drifted out to sea and have sunk to the bottom when waterlogged. Its body fits the tube of the chosen twig as a glove fits a finger, and its great chelæ are modified so as to form, when pressed together, a tight-fitting stopper to the mouth of the tube. There is just one chink left as a peep-hole between the cork and the tube-wall. *Pylocheles* has a very strange distribution, being only found in the Caribbean Sea and in East Indian waters.

Another crustacean that has its burrow in sunken driftwood is the little scorpion-lobster (*Callianassa lignicola*), found in the Andaman Sea, in 185-250 fathoms, by my successor Dr Anderson.

The *Stenopidea* and scorpion-lobsters (*Thalassinidea*) are a feeble folk, and several of them are known to habitually seek shelter in sponges and zoophytes. Such are *Spongicola*, one species of which has been discovered in the Andaman Sea in 170-300 fathoms;

THE STOPPER-FISTED HERMIT-CRAB.

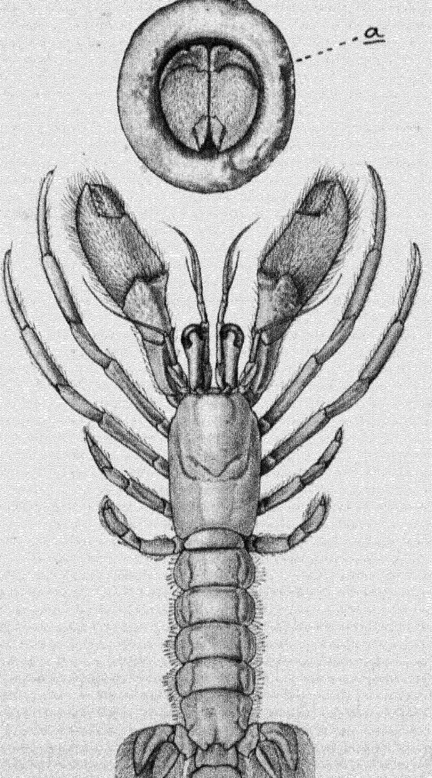


FIG. 65.—*Pylocheles miersii*, discovered by Dr A. R. S. Anderson, in the Andaman Sea, at 185 fathoms. The upper figure (*a*) gives an end-on view of the animal bottled in its natural tube of water-logged mangrove or bamboo, with its bent "hands" closing the mouth of the tube like a cork. The lower figure shows the animal in a conventional position after removal from its refuge.

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*Richardina*, a species of which Dr Anderson found imprisoned in a glass-rope sponge (*Hyalonema masoni*, F. E. Schulze) dredged in the Andaman Sea at a depth of 498 fathoms; and *Iconaxiopsis laccadivensis* (Fig. 66), which has been found lurking in the branches of that strange armour-plated deep-sea zoophyte *Calypterinus allmani*.

A curious modification of legs, apparently due to the peculiarities of its habitat, is shown by a crab, *Ptenoplax notopus* (Fig. 55), which lives in the Bay of Bengal in 100-250 fathoms, in certain places where the bottom consists of a very soft and very copious silt. In this little creature the legs are thickly fringed along both edges, so that the last pair, which are carried obliquely behind the body, are more like feathers than legs, the probable object being to give a light but extensive support, on the principle of the snow-shoe, so as to keep the body from sinking too far into the soft ooze.

Many good instances of commensalism have been observed among the deep-sea Crustacea collected by the *Investigator*. That of *Chlænopagurus andersoni* (Fig. 2), a hermit-crab from 102 fathoms off the Malabar Coast, which is protected by a blanket of sea-anemones instead of by an ordinary mollusk shell, has already been sufficiently noticed. Another well-known hermit, found in deep water all the world over, is *Parapagurus pilosimanus* (Fig. 67), which at an

early period of its existence betakes itself to a cast-off shell: the outside of the shell soon becomes appropriated by a colony of zoophytes, and as the two kinds of creatures grow, they gradually absorb the shell, until at last they come into actual contact, the hermit-crab finally being embedded in the common tissue of the zoophytes.

The partnership existing between the little crabs of the genus *Pinnoteres* and various kinds of bivalve mollusks has been known since the days of the ancient Greeks. New instances of it are discovered every day, but the only case known to occur in the deep-sea is one brought to light by Dr Anderson of the *Investigator*. In this case a *Pinnoteres* was found lodging in the mantle-cavity of a large *Lima* dredged off the Travancore coast in 430 fathoms.

We have in former chapters taken some account of the sounds made by certain Crustacea of the shore, but there is at least one deep-sea crab which is furnished with the means of making its own music. This is *Psophetius stridulans* (Fig. 52), from 170-420 fathoms, on whose "arm" there is a large upstanding spine so placed that it can be brought to play, like a quill upon a file, across a specially-roughened knob below the orbit. Both sexes possess this means of emitting a dismal noise, so that if it is of any use, as to which there may be some doubt, it may perhaps be brought into the category of organs of defence.

TWO CHARACTERISTIC DEEP-SEA CRUSTACEANS.

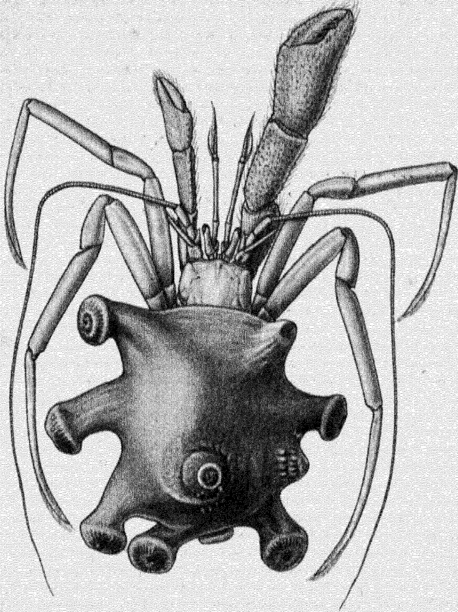

FIG. 67.—*Parapagurus pilosimanus*, with the zoophyte messmates that make its house.

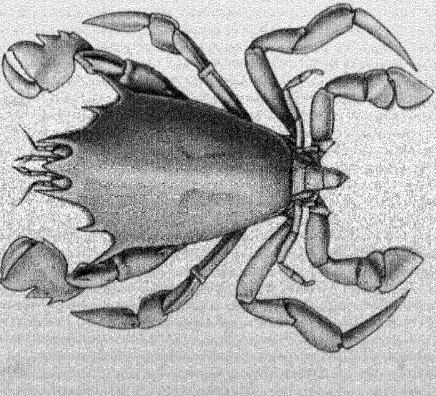

FIG. 69.—*Lyreidu channeri*, Channer's Frog-crab, from 200-400 fathoms.

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An undoubted weapon of defence is the bayonet telson of *Glyphocrangon* (Fig. 52). In this animal, as in *Plastocrangon* (Fig. 56), the telson and the two abdominal segments immediately in front of it, interarticulate by means of singularly-perfect movable dovetail joints, which, while permitting the freest movement of all three segments, enables them at any moment to be firmly locked together in such a way that an enemy is liable to transfix itself on the dagger-like telson. Another example of the armoury of the deep is the acute, serrated, antennal scale of *Hoplophorus*, which also has a sort of locking joint.

Among the temperate-zone Crustacea found in the depths, but not in shallow water, in Indian latitudes, the *Lithodea* are worthy of mention. These singular crustaceans are hermit-crabs in all their organisation, and yet they have a superficial resemblance to crabs which is quite misleading; but a certain tendency to lopsidedness, as well as the presence of an antennal scale and the curious position of the almost rudimentary last pair of thoracic legs, which are carried inside the branchial chamber, at once bewray them.

Another genus of the temperate zones which is represented in the cool depths of Indian latitudes, is the small frog-crab *Lyreidus*. One species, *Lyreidus channeri* (Fig. 69), is very often dredged in 200-400 fathoms off the coasts of India and Ceylon. Uncrab-

like though this little animal may look, yet the structure of its abdomen, and of the eyes and antennæ and of the carapace in the vicinity of those organs, plainly declare its Brachyuran affinities.

In conclusion, I may mention that final reports on the *Investigator* deep-sea Crustacea were issued as Indian Museum publications in 1899 and 1901, and that almost all the noteworthy species have been figured in the *Illustrations of the Zoology of the "Investigator."*

A DECEPTIVE HERMIT-CRAB OF THE LITHODES GROUP.

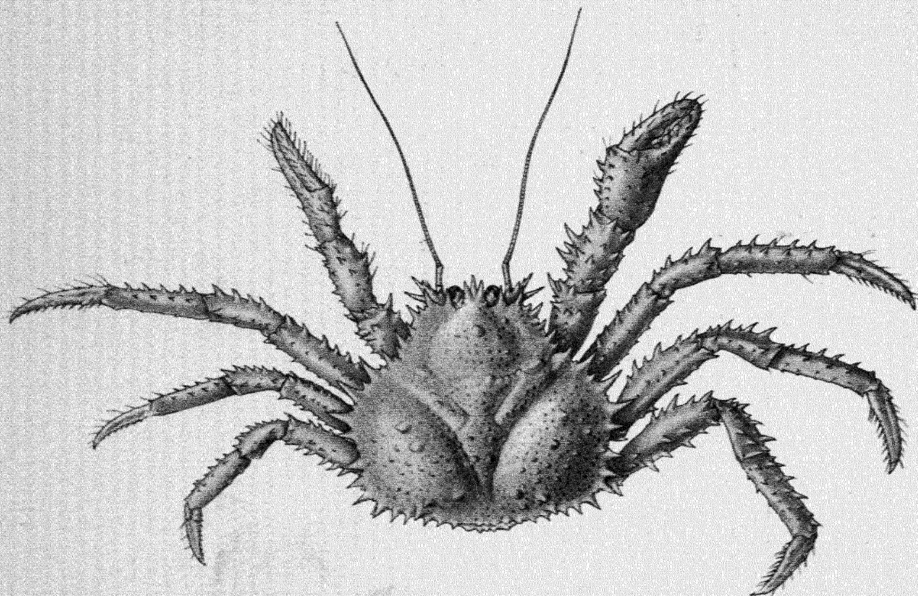

FIG. 68.—*Paralomis indica*, a crab-like Hermit-crab, from off the Travancore coast, 430 fathoms. The last pair of legs are much reduced in size, and are folded out of sight.

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# CHAPTER XIX

## OF THE DEEP-SEA MOLLUSCA AND MOLLUSCOIDA OF THE INDIAN OCEAN

Between the depths of 100 and 2000 fathoms a great many species of Mollusca have been dredged by the *Investigator*, and most of them have been described by Mr E. A. Smith, in various papers published in the *Annals and Magazine of Natural History*, from the year 1894. They belong to the following groups:—

| | | | |
|---|---|---|---|
| Gastropoda, | 68 | species. | |
| Scaphopoda, | 6 | " | |
| Cephalopoda, | 10 | " | (described by Mr E. S. Goodrich). |
| Lamellibranchiata, | 44 | " | |

Of the Gastropods, the dweller in the remotest depths is *Pontiothauma mirabile*, E. A. Smith, a large blind species with a colourless shell, surprisingly like that of the common whelk of northern seas: a unique specimen of this large species, which has neither eyes nor radula, was dredged in the Laccadive Sea at a depth of 1250 fathoms, on a bottom of blue mud, the temperature being 36° Fahr.; its shell was nearly 5¼ inches long.

Twenty-two per cent. of the Indian deep-sea Gastropods belong to the genus *Pleurotoma*, a genus which is also prolifically represented in the shallow waters of these warm latitudes. Among them is *Pleurotoma symbiotes* (Fig. 14), first found off Cape Comorin at a depth of over 1000 fathoms, which has already been mentioned as invariably having its shell encrusted with a commensal zoophyte of the genus *Epizoanthus*. *Turbo indicus*, which lives near the 600-fathom line in the same neighbourhood, is another hospitable species which gives a lodging on its living shell to a sponge and a barnacle (*Scalpellum*). This *Turbo* is of further interest, because, according to Mr E. A. Smith, it is possibly only a variety of *Turbo peloritanus*, a deep-water species of the Mediterranean and North Atlantic.

One of the commonest and most characteristic Gastropods of the edge of the abyssal slope in the Bay of Bengal, is *Rostellaria delicatula*, Nevill (Fig. 70), a small and delicate, but very handsome species. It furnishes a good illustration of the fact that deep-water species as a rule have much thinner and lighter shells than their kindred of the shore.

A Gastropod which is found in the Andaman Sea at almost every haul between 100 and 300 fathoms, is the Japanese *Xenophora pallidula* (Fig. 71): this creature also has naturally a thin and translucent shell, which, however, it fortifies by building into it a

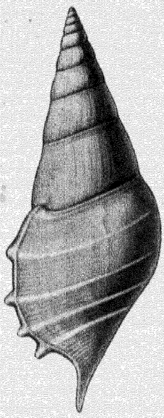

FIG. 70.—*Rostellaria delicatula*, very common in the Bay of Bengal near the 100-fathom line, and one of the most characteristic deep-sea Mollusca of India.

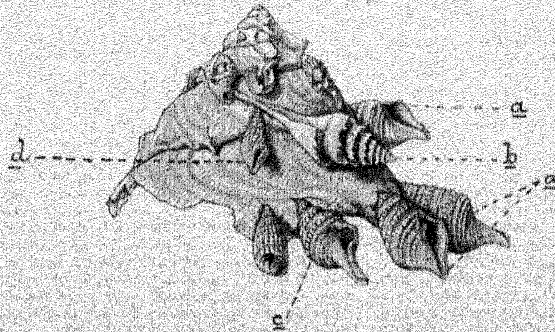


FIG. 71.—A specimen of *Xenophora pallidula*, from the Andaman Sea, 185 fathoms; reduced. Among the dead shells used as a fortification are—(*a*) *Pleurotoma congener*, (*b*) *Pleurotoma travancorica*, (*c*) *Pleurotoma carinata*, and (*d*) *Drillia captiva*. The dead shells utilised as building-material are not stuck on indiscriminately, but are arranged along the edge of each whorl.

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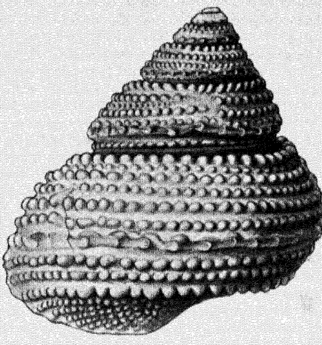

FIG. 72.—*Astralium bathyraphe*, from off the Maldives, 210 fathoms; slightly enlarged.

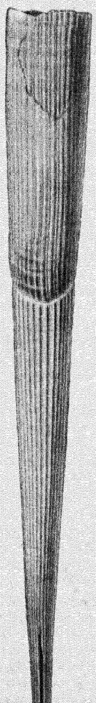

FIG. 73.—*Dentalium magnificum*, a large tooth-shell from 600-800 fathoms.

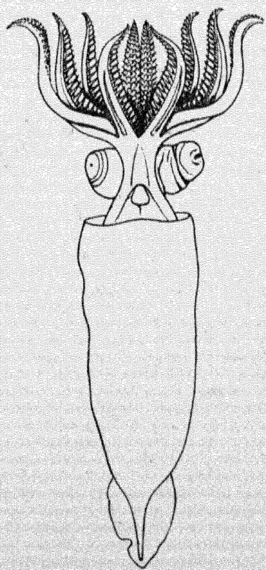

FIG. 74.—*Taonius abyssicola*, a large-eyed cuttle-fish, from 902-1370 fathoms; reduced. The eyes are swollen and burst.

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sort of *chevaux-de-frise*, formed of the dead shells of other species, or of bits of shingle, or even, should no other material be at hand, of bits of slag and cinder shot overboard from steamships. The individual here figured (Fig. 71) had, with the most reckless disregard of the claims of science, appropriated to its own base use the shells of three new *Investigator* species, namely *Pleurotoma congener* (*a*, Fig. 71), *Pleurotoma travancorica* (*b*, Fig. 71), and *Drillia captiva* (*d*, Fig. 71), the last being a unique "type."

One of the handsomest of our Indian deep-sea Gastropoda is *Astralium bathyraphe*, E. A. Smith (Fig. 72), whose shell is not only exquisitely sculptured, but is also of a beautiful magenta colour rarely seen in the shells of the deep sea. *Astralium*, like *Xenophora*, is a type that was originally discovered in Japan.

Before leaving the Gastropoda, mention must be made of the curious geographical distribution of the key-hole limpet *Puncturella asturiana*, which has been taken off the West Indies in 390 fathoms, in the Bay of Biscay in 600-1100 fathoms, and at the southern end of the Bay of Bengal in 609 fathoms.

The Scaphopoda, or tooth-shells, hitherto dredged in deep water in Indian latitudes, number six species, all belonging to the genus *Dentalium*, and all living on soft muddy bottoms in the neighbourhood of Ceylon. One of them, *Dentalium magnificum*, E. A.

Smith (Fig. 73), from 600-800 fathoms, has a shell [illegible] inches long, while another, *Dentalium profundorum*, E. A. Smith, from 675 fathoms, reaches a length of nearly 3½ inches.

Ten species of CUTTLEFISHES have been discovered in the nether waters of the Indian sea-basins, and have been described by Mr E. S. Goodrich in the *Linnean Society's Transactions* for 1896. The deepest dweller of them all is *Taonius abyssicola*, Goodrich (Fig. 74), from 902-1370 fathoms, and there can be no doubt that this species really lives far below the surface, for it has the dark purple-brown colour, the frail flesh, and the large eyes—burst by removal from the accustomed pressure of the depths—which are found only in abyssal animals. On the other hand, *Chiroteuthis pellucida*, Goodrich (Fig. 75), though dredged in 922 fathoms water, and though favoured with largish eyes, probably swims not far from the surface, for the only specimen captured was alive when brought on board, and did not appear to suffer more acutely than any ordinary cuttlefish would have done by removal from water. Some of the deep-sea cuttlefishes possess luminous organs which are often arranged with great regularity; among these are two species of *Abralia* (Fig. 76), which have been taken between 90 and 320 fathoms in these seas.

The BIVALVES dredged from the deep in Indian latitudes include a considerable number of forms

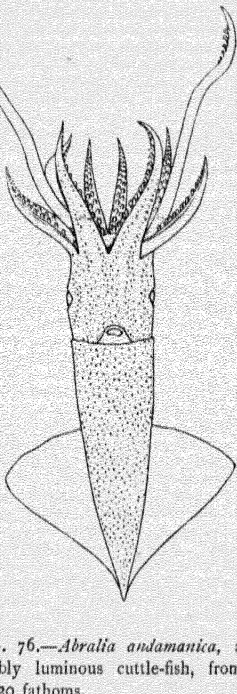

FIG. 76.—*Abralia andamanica*, a probably luminous cuttle-fish, from 188-320 fathoms.

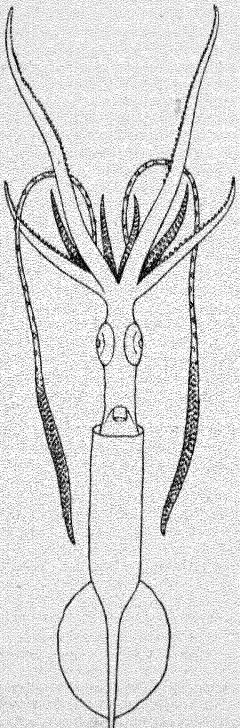

FIG. 75.—*Chiroteuthis pellucida*, from the Bay of Bengal, 922 fathoms.

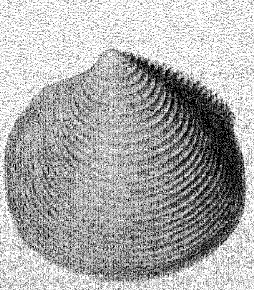

FIG. 77. — *Lucina spinifera*, a British bivalve that also lives in the depths of the Bay of Bengal.

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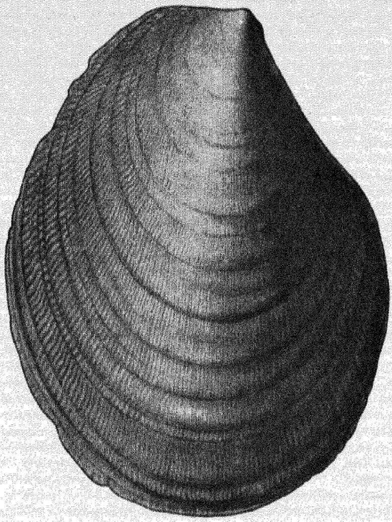

FIG. 78.—*Lima indica*, from off the Travancore coast, 430 fathoms. This species is supposed by its author, Mr E. A. Smith, to be hardly more than a variety of the Norwegian *Lima excavata*.

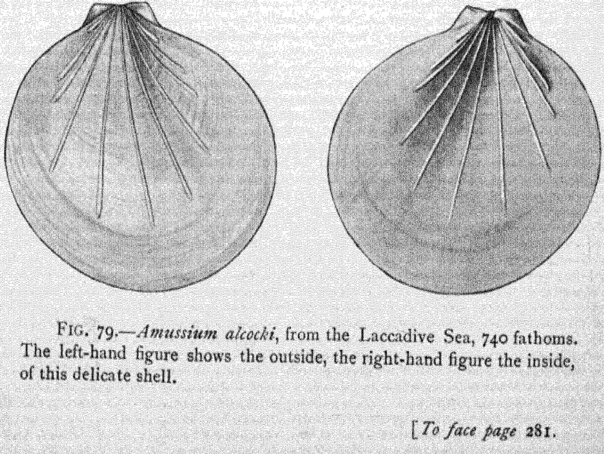

FIG. 79.—*Amussium alcocki*, from the Laccadive Sea, 740 fathoms. The left-hand figure shows the outside, the right-hand figure the inside, of this delicate shell.

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whose shallow-water sisters are characteristic of cold and temperate seas: such are *Lima*, *Nucula*, *Nuculana*, *Yoldia*, and *Abra*. It is even the fact, according to Mr E. A. Smith, that the British species *Lucina spinifera*, Montagu (Fig. 77), is found in the Bay of Bengal at a depth of 200-350 fathoms, where the bottom-temperature was found to be 53°-49°.8 Fahr. Again, *Lucina bengalensis*, E. A. Smith, from 410 fathoms in the Bay of Bengal, is very closely related to, and *Solenomya patagonica*, E. A. Smith, is actually identical with, respective species dredged by the *Challenger* in Magellan Strait in 245 fathoms. Furthermore, *Limopsis indica*, E. A. Smith, which is common in the Laccadive Sea at depths of 142-1200 fathoms, is regarded by Mr Smith as only a modification of, and *Poromya tornata*, Jeffreys, from 1997 fathoms in the Bay of Bengal, as identical with, respective species occurring in the Mid Atlantic at 1850 fathoms. Finally, in Mr Smith's opinion, *Lima indica*, E. A. Smith (Fig. 78), from 430 fathoms off the coast of Travancore, is hardly more than a variety of the Norwegian *Lima excavata*, Chemnitz, and of the Japanese *Lima goliath*, Sowerby. *Lima indica* is also interesting as, like so many shallow-water bivalves, it harbours a little crab, *Pinnoteres abyssicola*, in its mantle-chamber.

The characteristic deep-sea genus of scallops, *Amussium* (Fig. 79), is represented in Indian latitudes by five species, one of which, *Amussium soli-*

*tarium*, E. A. Smith, was dredged at the profound depth of 1803 fathoms. *Amussium alcocki*, E. A. Smith (Fig. 79), is a common species of the Laccadive Sea between 696 and 740 fathoms, and has also been taken off the west coast of the Andamans in 561 fathoms.

One of the most beautiful and most characteristic bivalves of the Bay of Bengal on the verge of the abyssal slope is *Nucula fultoni*, E. A. Smith (Fig. 80), the lustre of whose shell, when the outer protective epidermis is removed, is like that of the choicest pearls. In form and sculpture, as well as in brilliance, this shell is one of those gems of purest ray serene, which, in fine accord with the poet's prophetic imagination, the dark unfathomed caves of ocean bear.

Another species that shares the habitat of *Nucula fultoni* is *Yoldia angulata*, Sowerby (Fig. 81), an elegant little shell covered with a shiny olive-green epidermis.

Of the characteristic deep-water genus *Cuspidaria*, whose shell is produced to form a long tube for the protection of the siphons, five species have been discovered by the *Investigator*, *Cuspidaria macrorhynchus*, E. A. Smith (Fig. 82), from off the Laccadives in 636 fathoms, being the one that lives at the greatest depth.

Of the bivalve MOLLUSCOIDA, only two species, both

FIG. 80.—*Nucula fultoni.* This beautiful species is one of the commonest bivalves of the northern end of the Bay of Bengal, at depths ranging from 190 to 400 fathoms.

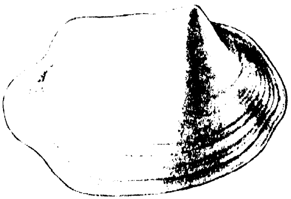

FIG. 81.—*Yoldia angulata*, from the Bay of Bengal, 258-405 fathoms; enlarged.

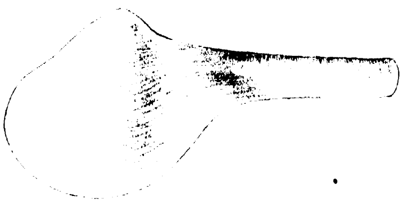

FIG. 82.—*Cuspidaria macrorhynchus*, from the Laccadive Sea, 636 fathoms; enlarged.

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IN MEMORY OF JOHN DAVIS:

A LARGE DEEP-SEA LAMP SHELL.

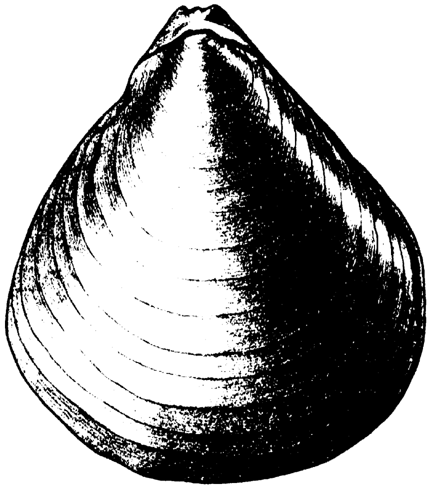

FIG. 83.—*Terebratula Johannis-Davisi*, a very large Brachiopod from off the Maldives, 719 fathoms. Only a single specimen was dredged, and it is somewhat singular in not being bilaterally symmetrical.

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belonging to the genus *Terebratula*, have been dredged by the *Investigator* in the regions bordering on the abyss. One of them is a beautifully-sculptured species of small size, whose stalk ends in a bunch of fine threads, each of which is anchored to a shell of Globigerina or some other tiny foraminifer: this species was found in the Laccadive Sea, between 865 and 880 fathoms. The other, which is of remarkably large size, its shell being close on 3 inches long and nearly 2¼ inches in greatest breadth, was dredged off the North Maldive Atoll in 719 fathoms on a bottom of fine coral sand. This species (Fig. 83) is further remarkable in having a shell that is not quite bilaterally symmetrical. I have named it after the great Elizabethan navigator, John Davis, who appears to have been one of the first Englishmen to make mention of the Maldive Islands, and to hold converse with their inhabitants, whose ambassador greatly impressed John Davis with his "princely spirit, his behaviour so sweet and affable, his countenance so modest, and his speech so graceful."

## CHAPTER XX

### OF THE DEEP-SEA ECHINODERMS OF THE INDIAN OCEAN

THE depths of the sea appear to be quite as well populated as are the shallow waters near shore by members of the great marine phylum *Echinoderma*, which includes the sea-lilies and feather-stars, the starfishes and brittle-stars, the sea-urchins, and the sea-cucumbers (*Holothuroidea*), and in Indian latitudes alone we already know of nearly 200 species that dwell below 100 fathoms.

Of STARFISHES the *Investigator* has already discovered more than sixty species, of which no less than sixteen were dredged in depths exceeding 1500 fathoms, but none of them differ in any marked degree from their kindred near shore, though as a rule they belong to different genera.

Among the characteristic starfishes of the profound abysses (1500-2000 fathoms) are the large and handsome Pararchasters, the delicate little Freyellas, the curious *Porcellanasteridæ* which appear to gorge on ocean mud, as worms do, and the Marsipasters and Hymenasters which carry their eggs in a nest formed

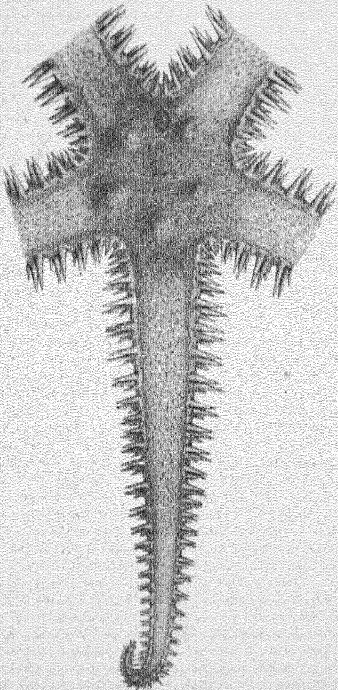

FIG. 84.—*Pontaster hispidus*, from the Laccadive Sea, 1000 fathoms. Back view, showing the plots of papules at the bases of the rays. Only one ray is represented at full length.

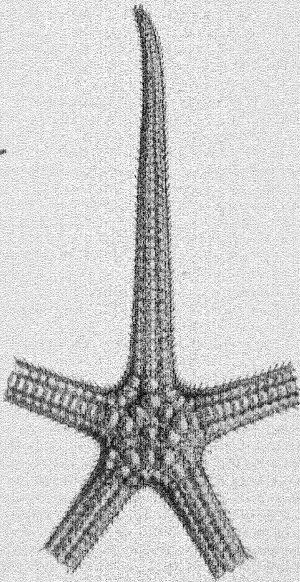

FIG. 85.—*Zoroaster zea*, from the Laccadive Sea, 597 - 1200 fathoms. Back view, showing the curious maize-like plates which encase the body. Only one ray is drawn in its entirety.

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of their own dorsal integument. All these have been dredged in the Bay of Bengal.

Near the 1000-fathom contour-line in these seas we meet with the Pontasters (Fig. 84), and the Zoroasters (Fig. 85). The former are remarkable, like the Pararchasters, for having their breathing-organs (*papulæ*) grouped into little raised plots, situated one at the base of each ray, instead of scattered at random over the whole dorsal surface. The Zoroasters are distinguished by their small disk and long rigid rays, and by their bunches of forceps-like pedicellariæ.

Among the most handsome of the numerous species found as a rule inside the 500-fathom contour-line, in these latitudes, are the Nymphasters, whose exoskeleton forms a mosaic of marvellous symmetry and beauty. In *Nymphaster florifer* (Fig. 86) the radial plates of the disk are larger and more prominent than the inter-radial plates, and so form a floral pattern of five raised petals.

Four species of the beautiful *Brisinga*, a brittle form with many rays radiating from a small round disk, called after its fancied resemblance to the flaming breast-ornament, or Brising, of the Scandinavian goddess Freya, have been found here—two off the Andamans, at 405 and 561 fathoms, and two off the Malabar coast and Laccadives, at 559 and 1043 fathoms. *Brisinga* was first discovered and named

by the Norwegian poet, Asbjornsen, in Hardanger Fjord, and was for some time supposed to be confined to the North Atlantic, but it has since been found to have a wide range in deep water. All our specimens of this fragile starfish, having been dredged up quickly by means of the wire rope, are particularly badly broken: I therefore appeal to my successors in the *Investigator* to pray that the rope may be very slowly reeled in when the ship is dredging on known Brisinga-ground, in the hope of getting specimens suitable for the draughtsman.

Of the typical cold-water genus *Asterias*, one species, very like the North Atlantic *Asterias glacialis*, is known to exist at depths (120-250 fathoms) in the Andaman Sea, where the temperature is between 50° and 60° Fahr. The genus *Palmipes*, which likewise belongs to the temperate zone, also occurs in the Andaman Sea at depths of over 100 fathoms.

With the exception of the *Porcellanasteridæ*, which appear to feed on mud for the sake of any organic nutriment that it may contain, the starfishes of the deep sea seem, like their shallow-water relatives, to live largely on mollusks, though the remains of prawns and amphipods have been found in the stomachs of some of them. In fact, the only marked difference between the abyssal starfishes and those living near shore seems to be one of colour, the colouring of the former being most wonderfully brilliant.

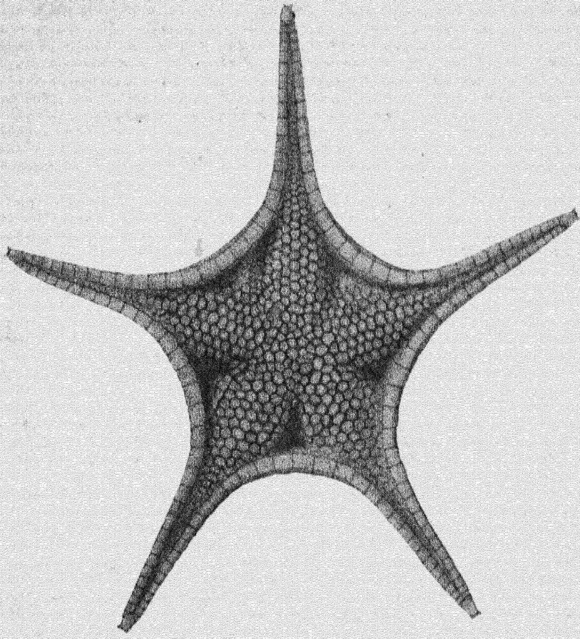

FIG. 86.—*Nymphaster florifer*, from off the Andamans, 130-250 fathoms.

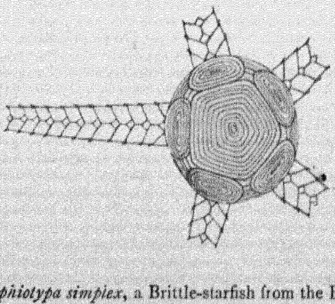

FIG. 87.—*Ophiotypa simplex*, a Brittle-starfish from the Bay of Bengal. 1997 fathoms; considerably enlarged.

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The commonest hue is a vivid salmon red, but orange as well as most liberal-conceited shades of terra-cotta and pink are often seen; and a few species are a rich chestnut brown. The Brisingas and Freyellas are usually of a flaring vermilion colour, but *Pedicellaster atratus* from 220-419 fathoms is black as jet, and *Palmipes pellucidus* is like ground glass. As a rule the colours are simple and uniform, but *Milteliphaster wood-masoni* from 230-290 fathoms is a brilliant exception, for in this truly magnificent species every one of the plates of the exoskeleton is picked out in red, the result showing as a scarlet network on a yellow background like the full dress of the most gorgeous of cavalry.

Wherever the bed of the sea is calcareous, there in these latitudes, in depths up to 1000 fathoms and over, we find swarms of BRITTLE-STARFISHES (*Ophiuroidea*), as we also do on the rich mud of the abyssal slope of the Malabar coast; but except in their colours, which are commonly pink, or scarlet and purple, or violet, or bright orange, they do not differ in appearance and structure from the sombre-hued types that live upon the reefs, with which indeed, many of them are congeneric.

Dr Koehler, who has named and described the *Investigator* collections, distinguishes fifty-six deep-sea species, of which nine were dredged in depths exceed-

ing 1500 fathoms. Among them is *Astronyx loveni*, a Norwegian species, also inhabiting deep water off Japan, which was taken by the *Investigator* in 406 fathoms off the Travancore coast. Another interesting species is *Ophiotypa simplex*, Koehler (Fig. 87), from the tremendous depth of 1997 fathoms, which, though adult, retains an embryonic simplicity in the form of its exoskeleton, the arrangement of the dorsal plates of which is suggestive of the elements of the cup of a Crinoid.

Though the CRINOIDS, both Feather-stars and Stalked Sea-lilies are represented in the depths of the seas of India, the number of species discovered by the *Investigator* is very small, nor have they yet been sufficiently examined.

On the other hand the abyssal SEA-URCHINS of Indian latitudes are fairly abundant in species and amazingly prolific in individuals: in fact, many of our deep-sea Echinoids, such as *Phormosoma*, *Dorocidaris*, *Palæopneustes* (Fig. 22), and *Lovenia gregalis* (Fig. 88), appear to be in the highest degree gregarious. Except that their shells are much thinner, and their spines sparser and more delicate, the sea-urchins of the depths are not strikingly different in general appearance, or even in colour, from those of the regions near shore, though of course they are, in the main, utterly different, generically, from any of the littoral species of these latitudes.

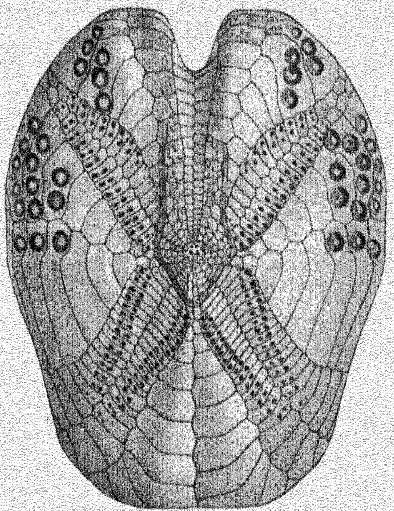

FIG. 88.—*Lovenia gregalis*, from the Bay of Bengal, 475 fathoms. The hair-like and bristle-like spines with which it is covered have been removed.

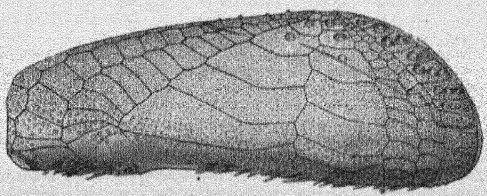

FIG. 89.—*Homolampas glauca*, from the Bay of Bengal, 1644 fathoms. Most of the spines have been removed.

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Among characteristic deep-sea genera, *Homolampas* (Fig. 89), *Prionechinus*, *Pourtalesia*, *Cionobrissus*, and *Phormosoma*, are all found in Indian waters, *Homolampas* at the great depth of 1644 fathoms, and *Prionechinus* at the same depth, and also at the greater depth of 1840 fathoms. The only genera of the Indian littoral that are also represented on the abyssal slope are *Lovenia*, one species of which (*Lovenia gregalis*, Fig. 88) has been found in abundance in 475 fathoms, and *Brissopsis*, of which one species has been dredged in 609-753 fathoms in the Bay of Bengal. Like their shallow-water kindred, the sea-urchins of the deep sea are, as a rule, remarkable for the scrupulous cleanness of their outside, but the great spines of the bathybial Cidarids are often encrusted with barnacles and sponge.

The HOLOTHURIANS of the Indian abysses are for the most part absolutely different from those of the off-shore waters. Most of them belong to Theel's Order *Elasipoda*, an order "which cannot be derived from the present shallow-water fauna, but must have originated from a past type that certainly bore another stamp." A few belong to the apodous family *Molpadidæ*.

The Elasipoda, which are purely abyssal forms, are strangely unlike the familiar sea-cucumbers of the reefs, for not only have they become profoundly modi-

fied to suit the peculiar conditions under which they live, but they also retain certain ancestral leanings which have been lost by their more modern adult-relatives of the shallow water, and are devoid of certain specially-Holothurian characters which the latter have acquired. These Elasipods, of which fourteen species have been dredged by the *Investigator* in depths ranging from 200 to 2000 fathoms, have, in fact, more the shape of large slugs than of ordinary Holothurians. Their body is bilaterally symmetrical: its ventral surface, where alone tube-feet are found, forms a broad, flat sole for crawling, the breadth of which is often increased by a marginal fringe or fin; the back is usually humped; and, as in a crawling animal, the mouth is either situated upon or turned towards the ventral surface, to facilitate browsing. Though their tissues are often as soft as jelly, yet some of them, such as Deima (Fig. 90), have a "shell" of calcareous plates like the test of a sea-urchin on an attenuated scale.

As regards their habits, the deep-sea Holothurians gorge on mud, just as their shallow-water kindred do, and some of them appear to be strongly gregarious.

In *Eupyrgus scaber*, an Arctic species which is also found in the Laccadive and Andaman Seas in 405-738 fathoms, we have a strange geographical range paralleled by that of the brittle-star *Astronyx loveni* before mentioned.

A DEEP-SEA HOLOTHURIAN.

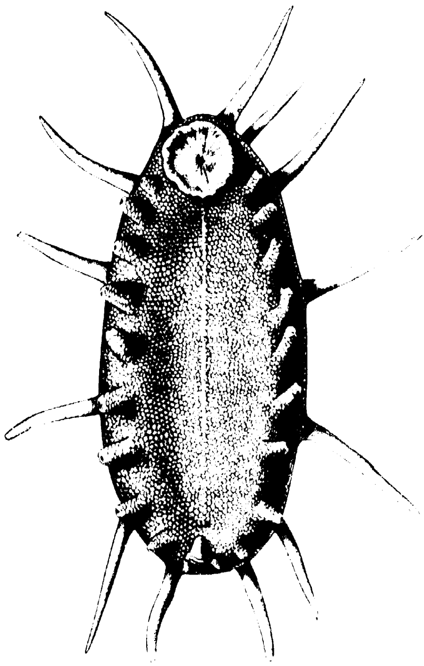

FIG. 90.—A species of *Deima*, from the Bay of Bengal, 1748 fathoms. Ventral view, showing the flat, sole-like, crawling surface, with the modified tube-feet round its edge, and the mouth at its fore end.

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## CHAPTER XXI

### OF THE ZOOPHYTES, SPONGES, AND CERTAIN OTHER MARINE INVERTEBRATES COLLECTED BY THE "INVESTIGATOR" IN THE DEEP SEA

MANY kinds of ZOOPHYTES grow in the depths of the sea, and not a few have been dredged up by the *Investigator*, though often at the expense of much dredging-gear, for these beautiful flowers of the sea flourish most on rocky ground where the trawl is apt to foul and get broken. There is plenty of such ground off the west coast of the Andamans, and off the south and east coasts of Ceylon, and also in the neighbourhood of the Laccadives, and in these different regions many species of *Alcyonacea* have been collected. At one spot, not far from Trincomalee, M'Ardle found abundance of a beautiful pink coral which appears to be identical with the precious coral of the Mediterranean.

In the open plain of the Bay of Bengal, sea-anemones and sea-tassels (*Umbellula*) have been dredged in the greatest depths (1803-1997 fathoms), at which the trawl has been worked.

Gaudy as the zoophytes of the reefs often are, those of the dark unfathomed caves of ocean, though they are born to blush unseen, and to waste their beauty in the pit, undeniably surpass them both in richness and daintiness of colour. The Umbellulas range from deep purple and puce to pink, the sea-pens are arrayed in the same colours, though some are of a lurid orange: among the Alcyonarians we see every tint from a deep crimson to a faint rosy hue or a delicate lavender.

The branching bush-like zoophytes of the abysses, no less than those of the littoral zone, afford convenient cover for many kinds of worms, echinoderms, and crustacea, and we know of several instances where the guest has become specially adapted to its host. Again, the simple zoophytes, such as the sea-anemones, have the same tendency as their kindred of the shallow-water to form those permanent partnerships with hermit-crabs, of which two or three peculiarly perfect cases have already been mentioned.

The true STONY-CORALS (*Madreporaria*) exist even in the profound abysses of the ocean, though in the Indian basins, 1070 fathoms is the greatest depth at which, up to the present, they have been dredged. Of course they are all very different from the reef-building species, and with two exceptions our Indian deep-sea corals belong to genera very remote from those found anywhere near shore. Most of our

abyssal species are new to science, though several of them are very closely related to some of the fossil forms described by Seguenza from the Tertiary rocks of Sicily and southern Italy. Of those which are not new, at least two, namely, *Caryophyllia communis*, Seguenza and *Flabellum laciniatum*, Philippi, were inhabitants of the Tertiary Mediterranean, and still flourish in the Atlantic.

The majority of the deep-sea corals are simple—that is to say, do not form colonies by budding—and are of strikingly large size, one species (*Flabellum japonicum*, Moseley) growing as big as a coffee-cup. Some of them, however, are compound branching forms, which must, at times, in certain places, grow luxuriantly enough to give rise to veritable submarine reefs. Thus on the abyssal slope of the Travancore coast, at a depth of 430 fathoms, Dr A. R. Anderson, sometime an *Investigator* naturalist, dredged nearly half a ton of *Solenosmilia*, *Lophohelia*, *Desmophyllum*, and *Caryophyllia* at one tremendous haul. Even the simple corals, which do not branch, seem sometimes to be so prolific as to lead to the formation of abyssal sheets of limestone rock; for on one occasion, in the Laccadive Sea, the dredge, though it was on the bottom less than three hours, brought up from 1000 fathoms over 200 specimens of *Caryophyllia ambrosia* (Fig. 91), a large and very beautiful species with a dense and compact corallum: the same species was

dredged in quantity on another occasion, in the same sea, at 1070 fathoms.

Though they live under an enormous pressure, the soft parts and skeleton (corallum) of these deep-sea corals are far from being always delicate and fragile. For instance, in *Stephanotrochus* (Fig. 92), which is a characteristic deep-sea genus, the soft parts are thicker and more fleshy, and the skeleton is harder and denser than in most reef corals. But on this point, as usual, no hard and fast generalisations can be made, for in *Bathyactis* (Fig. 93), which is also a characteristic deep-sea genus, the soft parts are excessively delicate, and the skeleton is exquisitely thin and lace-like.

Among the noteworthy corals of the Andaman depths is *Deltocyathus andamanicus* (Fig. 94), dredged in 172-303 fathoms; it has a most beautifully sculptured disk-like corallum, and, perhaps, is not really distinct from *Deltocyathus italicus*, a fossil species from the Tertiary rocks of Italy, which still lives in the depths of the Atlantic.

The majority of deep-sea SPONGES belong to the class *Hexactinellida*, elegant forms whose skeleton consists of a delicate trellis-work of translucent six-rayed spicules of flint, of which the beautiful Venus' flower-basket and the curious glass-rope sponge are the most familiar museum examples. These sponges are rooted

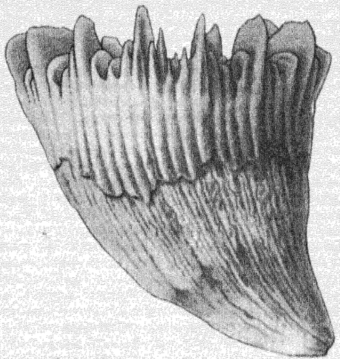

FIG. 91.—*Caryophyllia ambrosia*, from the Laccadive Sea, 1000 fathoms; enlarged twice.

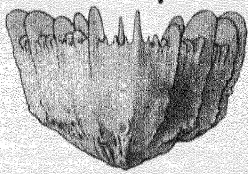

FIG. 92.—*Stephanotrochus nitens*, from off the Malabar coast, 740 fathoms.

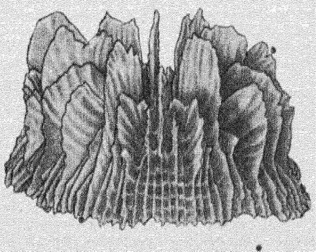

FIG. 93.—*Bathyactis stephana*, from the Bay of Bengal, 678-800 fathoms; slightly enlarged.

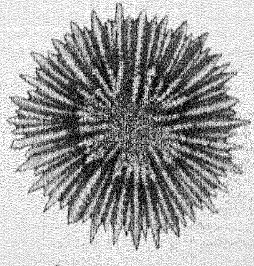

FIG. 94.—*Deltocyathus andamanicus*, from 172-303 fathoms; enlarged twice.

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in the ooze, either by a loose tuft of thread-like spicules resembling a wisp of spun glass, as in the Andaman bird's-nest sponge (*Pheronema raphanus*, F. E. Schulze, Fig. 18), or by a stiff hollow stem that looks something like a tube of asbestos, as in *Saccocalyx pedunculata*, F. E. Schulze (Fig. 95), but often they are merely tethered by a long anchor-rope of stout strands of glass tightly twisted together, as in *Hyalonema* (Fig. 96).

The Hexactinellida, which are now almost entirely confined to deep water, occur as fossils in almost every geological system from the Cambrian onwards. They are particularly abundant in rocks of Cretaceous age, and the flints of the White Chalk are now generally believed to have originated from Hexactinellid sponges whose skeletons were dissolved, and afterwards re-deposited as nodules round foreign bodies lying at the bottom of the Cretaceous Sea.

The species obtained by the *Investigator* are thirty-one in number, of which eight were dredged in depths exceeding 1500 fathoms, and they have been described —the majority being new to science—by Professor F. E. Schulze; of the few that were already known, two are wide-ranging species that also occur, on the one hand, in the North Atlantic, and, on the other hand, in Japanese seas.

More than a dozen of them are glass-rope sponges (*Hyalonema*) whose anchoring ropes are usually encrusted by zoophytes of the genus *Palythoa*, and by

barnacles of more than one kind. This is well shown in the figure of *Hyalonema masoni*, F. E. Schulze (Fig. 96), a species taken in the Bay of Bengal in 1748 fathoms, whose rope has been taken possession of by a crowd of barnacles to which Professor Weltner has given the name *Scalpellum squamuliferum.*

A very elegant Euplectellid sponge that shows to perfection the graceful trellis-work arrangement of the spicules of the skeleton, is *Dictyaulus elegans*, F. E. Schulze (Fig. 97), dredged in the Laccadive Sea at a depth of 705 fathoms.

As has been written in a former chapter, the sea-bottom in the southern two-thirds of the Bay of Bengal consists of almost pure globigerina-ooze formed of shells of dead FORAMINIFERA—*Globigerina*, *Pulvinulina*, and *Orbulina* predominating—which, for the most part, have fallen from somewhere near the surface. Similar ooze, though mixed with a good deal of other calcareous matter, occurs in the neighbourhood of the Laccadives.

All these shells are of minute size, but big Foraminifera — though by no means approaching the maximum of size for this group of animalcules—with shells compacted of numerous very fine particles of sand, have been dredged by the *Investigator* in the Andaman Sea. One of these, *Masonella patelliformis*, H. B. Brady (Fig. 98), dredged in 265 fathoms, attains a diameter of more than half an inch.

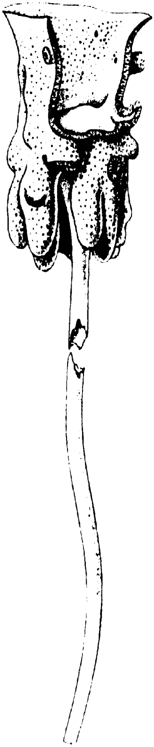

FIG. 95.—*Saccocalyx pedunculata*, from the Bay of Bengal, 1803 fathoms; reduced. The stalk by which the sponge is implanted in the soft ooze has been accidentally broken.

FIG. 96.—*Hyalonema masoni*, from the Bay of Bengal, 1748 fathoms; reduced. Only the upper part of the glass-rope, by which the sponge is anchored to the ooze, is represented, and it is overgrown with barnacles (*Scalpellum squamuliferum*).

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In this mere mention of the *Foraminifera*, I do not wish to advert to any matters of controversy, but I should like to place on record, as perhaps affecting in some slight way the vexed question of the nature and depth of the Chalk Sea, the results of the rough analyses, made by myself on board the ship, of the samples of calcareous ooze brought up from the depths while I was in the *Investigator*.

The ooze dredged in 1600 to 2000 fathoms in the open parts of the Bay of Bengal, remote from land of any sort—ooze which seemed to consist entirely of shells of *Foraminifera* with an admixture of nuggets of pumice—was soluble in hydrochloric acid to the extent of from 24 to nearly 75 per cent.

That dredged *in similar great depths* up to 1735 fathoms near the mouth of the Bay of Bengal, but in proximity to the Andaman Islands, was sometimes nearly entirely soluble, and was usually soluble to the extent of not less than 75 per cent.: this ooze contained large numbers of Foraminifera.

That dredged in the Arabian Sea, in 800 to 1100 fathoms, far from the influence of continental land, and considerably remote from the Laccadive banks and islands—ooze which seemed to consist entirely of shells of *Foraminifera*—yielded from 50 to 60 per cent. of its weight to hydrochloric acid.

Finally, the ooze dredged in depths ranging from 700 to 1370 fathoms in the immediate vicinity of the

Laccadive Islands gave up from 75 to 91 per cent. of its weight to hydrochloric acid.

In conclusion, I regret to say that though plenty of material has been collected by the *Investigator*, little or nothing has been published regarding the *Medusæ*, *Annelida*, *Polyzoa*, *Tunicata*, and *Pycnogonida* that exist in the depths of these northern reaches of the Indian Ocean.

A FLOWER-VASE SPONGE AND A LARGE PROTOZOON.

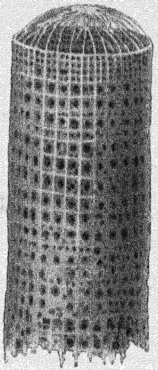

FIG. 97.—*Dictyaulus elegans*, a kind of Venus' Flower-basket, from the Laccadive Sea, 705 fathoms; reduced. Only the upper part of the sponge is represented.

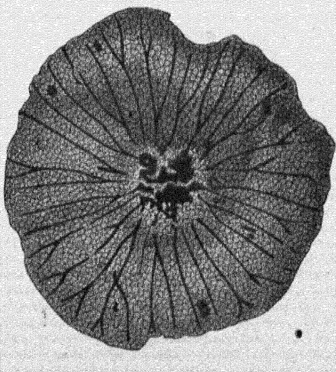

FIG. 98.—*Masonella patelliformis*, a Foraminifer with thick sandy test, from the Andaman Sea, 265 fathoms; enlarged five times.

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# PART III

# APPENDICES

# APPENDIX A.—*INVESTIGATOR* DEEP-SEA DREDGING-STATIONS.

## TABLE I.

### LIST OF *INVESTIGATOR* DREDGING-STATIONS IN THE DEPTHS OF THE ANDAMAN SEA.

| Serial No. of Station. | Date. | North Latitude. | East Longitude. | Depth in Fathoms. | Corrected Bottom Temp. Fahr. | Surface Temp. Fahr. | Nature of Bottom. |
|---|---|---|---|---|---|---|---|
| 5 | 8.12.87 | 8 miles S.E. of Cinque | Islands . . . | 500 | ... | ... | ... |
| 7 | 2.1.88 | Off Port Blair . . | ... | 267 | 50° | ... | ... |
| 8 | 5.1.88 | Off Cinque Islands . | ... | 650 | ... | ... | ... |
| 10 | 12.4.88 | 7½ miles E. of North Ci | nque Island . . . | 490 | ... | ... | ... |
| 10*a* | April '88 | 4 miles E. of Sisters Is | land . . . . | 645 | ... | ... | ... |
| 10*b* | " | 5 miles E. of North Ci | nque Island . . . | 474 | ... | ... | ... |
| 10*c* | " | Off Cinque Islands . | ... | 120-170 | ... | ... | ... |
| 13 | 25.4.88 | 7 miles S.E. by S. of | Ross Island . . . | 265 | ... | ... | ... |
| 15*a-b* | 29.11.88 | Off Port Blair . . | ... | 112-244 | ... | ... | Blue mud. |
| 113 | 13.11.90 | 12° 59′ | 93° 23′ 10″ | 683 | 42°.9 | 76°.5 | Blue mud. |
| 114 | 13.11.90 | 13° 21′ | 93° 27′ | 922 | 41°.2 | 80°.3 | Blue mud. |
| 115 | 9.12.90 | 11° 31′ 40″ | 92° 46′ 40″ | 188-220 | 56° | 83° | Green mud. |
| 116 | 9.12.90 | 11° 25′ 5″ | 92° 47′ 6″ | 405 | 47° | 82° | Green mud. |
| 221 | 9.12.96 | 13° 15′ | 93° 10′ | 198 | 54° | 82° | Sand, mud, & broken shells. |
| 222 | 21.12.96 | 13° 27′ | 93° 14′ 30″ | 405 | 48° | 79° | Green mud. |
| 228 | 13.4.97 | 13° 7′ | 94° 44′ 15″ | 640 | 43° | 86° | ... |
| 233 | 6.12.97 | 13° 17′ 15″ | 93° 10′ 25″ | 185 | 53°.5 | 79° | Sand. |
| 234 | 21.12.97 | 13° 50′ 30″ | 93° 26′ | 498 | 46°.7 | 78° | Green mud. |
| 235 | 8.4.98 | 14° 13′ | 93° 40′ | 370-419 | | ... | Grey mud. |
| 236 | 11.4.98 | 14° 8′ | 93° 8′ | 165 | ... | ... | ... |
| 236*a* | 11.4.98 | 13° 59′ | 93° | 172-303 | ... | ... | ... |
| 240 | 16.4.98 | 11° 32′ | 92° 46′ | 194 | ... | ... | ... |
| 241 | 17.4.98 | 10° 12′ | 92° 20′ 30″ | 606 | ... | ... | Green mud. |
| 251 | 28.10.98 | 10° 36′ 30″ | 93° 40′ 15″ | 1595-1622 | 41°-40°.5 | 83° | Globigerina-ooze. |
| 254 | 12.4.99 | 11° 16′ 30″ | 92° 58′ | 669 | 43° | 84°.3 | Green mud. |

## TABLE II.

## LIST OF *INVESTIGATOR* DREDGING-STATIONS IN THE DEPTHS OF THE BAY OF BENGAL.

| Serial No. of Station. | Date. | North Latitude. | East Longitude. | Depth in Fathoms. | Corrected Bottom Temp. Fahr. | Surface Temp. Fahr. | Nature of Bottom. |
|---|---|---|---|---|---|---|---|
| 1 | 25.3.85 | 21° 6′ 30″ | 89° 20′ | 405-285 | ... | ... | Green mud and pteropod-ooze. |
| 3 | 1887 | 40 miles S.W. of Akyab | | 100 | 62° | ... | ... |
| 3a | 26.8.87 | 17° 34′ | 87° 59′ | 1300 | ... | ... | ... |
| 4 | 6.11.87 | Off Ten Degree Channel | | 1045 | ... | ... | ... |
| 6 | 1887 | 19° 35′ | 92° 24′ | 272 | 50° | ... | ... |
| 8a | 23.1.88 | 20 miles W. of North Sentinel Island | | 780 | ... | ... | ... |
| 9 | 7.2.88 | S. by W. of North Sentinel Island | | 130-250 | ... | ... | ... |
| 11 | 19.4.88 | 5° 56′ 30″ | 91° 5′ | 1590 | 34°.7 | ... | ... |
| 12 | 19.4.88 | 6° 18′-6° 16′ | 90° 40′-90° 44′ | 1370-1540 | ... | ... | ... |
| 14 | 1887 (?) | 20° 17′ 30″ | 88° 51′ | 193 | ... | ... | ... |
| 54 | 13.4.89 | 12° 21′ 30″ | 92° 3′ 30″ | 780 | 40°.6 | 84°.6 | Globigerina-ooze. Trawl lost. |
| 55 | 13.4.89 | 30 miles W. of Cape Bluff (Andamans) | | 480-500 | ... | ... | Globigerina-ooze. |
| 56 | 24.4.89 | Between N. and S. Sentinel Islands | | 240-220 | ... | ... | Globigerina and coral sand. |
| 62 | 12.12.89 | 16° 45′-16° 44′ | 88° 32′ 30″-88° 19′ | 1439 | 35°.3 | 79°.7 | Brown mud. |
| 96 | 4.3.90 | 18° 30′ | 84° 46′ | 98-102 | 64° (?) | 80° (?) | Sand. |
| 97 | 14.3.90 | 18° 26′ | 85° 24′ | 1310 | 36°.2 | 80° | Olive mud. |
| 100 | 28.3.90 | 16° 55′ 41″ | 83° 21′ 18″ | 840 (?) | 41° | 79° | Brown mud. |
| 101 | 29.3.90 | 16° 11′ 15″ | 82° 30′ 30″ | 922 | 39° | 87° | Brown mud. |
| 102 | 1.4.90 | 15° 38′ | 82° 30′ | 920-690 | 39°.75 | 85° | Brown mud. |
| 110 | 3.11.90 | 9° 34′ | 85° 43′ 15″ | 1997 | 35° | 81°.3 | Globigerina-ooze. |
| 111 | 6.11.90 | 12° 50′ | 90° 52′ | 1644 | 35°.4 | 81° | Globigerina-ooze. |
| 112 | 7.11.90 | 13° 47′ 30″ | 92° 36′ | 561 | 44°.9 | 75°.4 | Grey mud. |

TABLE II.—*Continued.*

| Serial No. of Station. | Date. | North Latitude. | East Longitude. | Depth in Fathoms. | Corrected Bottom Temp. Fahr. | Surface Temp. Fahr. | Nature of Bottom. |
|---|---|---|---|---|---|---|---|
| 117 | 13.12.90 | 11° 58′ | 88° 52′ 17″ | 1748 | 35°.3 | 75°.5 | Globigerina-ooze, with large pieces of pumice. |
| 118 | 15.12.90 | 12° 20′ | 85° 8′ | 1803 | 35° | 78°.6 | Globigerina-ooze, with large pieces of pumice. |
| 120 | 24.12.90 | 15° 56′ 50″ | 81° 30′ 30″ | 240 | 52° | 79°.1 | Brown mud. |
| 129 | 11.1.92 | Off Godávari Delta | ... | 270 | 51° | ... | Brown silt. |
| 130 | 23.1.92 | Off Godávari Delta | ... | 281-258 | 51° | ... | Brown silt. |
| 131 | 21.2.92 | 16° 1′ | 81° 25′ | 410 | 45°.5 | 79° | Brown silt. |
| 132 | 31.3.92 | 12° 50′ | 81° 30′ | 475 | 45°.5 | 82° | Brown silt. |
| 133 | 1.4.92 | 15° 43′ 30″ | 81° 19′ 30″ | 678 | 42° | 82° | Brown mud, over clay. |
| 134 | 13.4.92 | Off Kistna Coast | ... | 753 | 41°.2 | 81°.8 | Brown mud, over clay. |
| 137 | 3.3.93 | 15° 4′ 7″ | 80° 25′ 7″ | 128 | ... | ... | Green mud. |
| 139 | 12.4.93 | 15° 25′ 6″ | 80° 25′ 7″ | 599 | ... | ... | Green mud. |
| 142 | 13.4.93 | 14° 13′ 8″ | 80° 24′ 2″ | 573 | 45°.3 | ... | Brown mud. |
| 154 | 3.1.94 | 14° 18′ 15″ | 80° 18′ 30″ | 80-110 | ... | ... | Grey mud. |
| 159 | 11.1.94 | 14° 5′ 55″ | 80° 25′ 20″ | 112 | ... | ... | Brown mud. |
| 160 | 17.1.94 | 13° 55′ 42″ | 80° 26′ 30″ | 110 | ... | ... | Brown mud. |
| 162 | 30.1.94 | 13° 51′ 12″ | 80° 28′ 12″ | 145-250 | ... | ... | Brown mud. |
| 163 | 31.1.94 | 13° 45′ 38″ | 80° 29′ 37″ | 210 | ... | ... | Brown mud. |
| 164 | 1.2.94 | 13° 41′ 27″ | 80° 32′ | 195-210 | 51°.2 | ... | Brown mud. |
| 165 | 2.2.94 | 13° 38′ 6″ | 80° 33′ 12″ | 475 | 45° | ... | Brown clayey mud. |
| 166 | 8.2.94 | 13° 34′ 55″ | 80° 32′ 12″ | 133 | 54°.8 | ... | Brown mud. |
| 168 | 14.2.94 | 13° 11′ 48″ | 80° 34′ 40″ | 105 | ... | ... | Brown mud. |

TABLE II.—*Continued.*

| Serial No. of Station. | Date. | North Latitude. | East Longitude. | Depth in Fathoms. | Corrected Bottom Temp. Fahr. | Surface Temp. Fahr. | Nature of Bottom. |
|---|---|---|---|---|---|---|---|
| 170 | 16.2.94 | 13° 1′ 6″ | 80° 36′ 56″ | 107 | ... | ... | Sand and soft brown mud. |
| 172 | 26.3.94 | 8° 40′ 10″ | 81° 17′ 45″ | 200-350 | 53°-49°.8 | 85° | Green mud. |
| 173 | 30.3.94 | 8° 35′ 45″ | 81° 17′ 45″ | 609 | 44° | 84°.5 | Brown mud. |
| 198 | 7.3.95 | 8° 55′ | 81° 17′ 30″ | 764 | 42°.2 | 81° | Green mud. |
| 199 | 15.4.95 | 8° 40′ | 81° 27′ 35″ | 800-637 | 41°-42°.2 | 83°.5 | Green mud. |
| 200 | 16.4.95 | 8° 28′ 40″ | 81° 32′ | 253 | 50°.7 | ... | Green mud. |
| 201 | 16.4.95 | 8° 44′ 40″ | 81° 20′ 15″ | 320-296 | 49°-49°.8 | 84°.5 | Green mud. |
| 202 | 17.4.95 | 7° 4′ 40″ | 82° 2′ 45″ | 695 | 42° | ... | Green mud. |
| 203 | 18.4.95 | 8° 50′ 30″ | 80° 25′ 30″ | 364 | 48° | 85°.5 | Green mud. |
| 255 | 13.4.99 | 9° 26′ 30″ | 91° 56′ 30″ | 869-913 | 40°.2-40°.7 | 84°.5 | Globigerina-ooze. |
| 262 | 25.1.00 | 8° 48′ | 80° 37′ | 805 | ... | ... | Green mud and sand. |
| 263 | 27.1.00 | 8° 56′ | 81° 9′ | 771-665 | ... | ... | Sand and soft green mud. |
| 264 | 28.3.00 | 10° 50′ 30″ | 80° 44′ 30″ | 987-900 | ... | ... | Mud. |
| 265 | 29.3.00 | 9° 32′ | 80° 59′ 30″ | 594-225 | ... | ... | Mud. |
| 266 | 30.3.00 | 8° 36′ 15″ | 81° 20′ 30″ | 542 | ... | ... | Mud. |
| 277 | 10.1.01 | 5° 48′ 15″ | 80° 56′ | 859-880 | 35°.5 (?) | ... | Green mud and sand. |
| 278 | 11.1.01 | 6° 52′ (?) | 81° 11′ | 1912 | 36° | ... | Green mud and sand. |
| 279 | 18.3.01 | 11° 35′ 15″ | 80° 2′ 15″ | 300 | ... | ... | Stiff green mud. |
| 280 | 19.3.01 | 11° 29′ 45″ | 80° 2′ 30″ | 446 | ... | ... | Mud and sand. |
| 281 | 20.3.01 | 11° 15′ 15″ | 80° 7′ | 300 | ... | ... | Brown mud. |
| 282 | 3.4.01 | 10° 8′ | 80° 49′ 30″ | 498-726 | ... | ... | Green mud, stones, sand. |
| 283 | 4.4.01 | 8° 53′ 15″ | 81° 20′ 30″ | 1086 | 35°.5 (?) | ... | Coral. |
| 284 | 5.4.01 | 7° 55′ | 81° 47′ | 506 | ... | ... | Coral. |
| 285 | 6.5.01 | 5° 55′ 15″ | 81° 33′ 30″ | 1571 | 36° | ... | Soft green mud. Trawl and 2200 fathoms rope lost. |

TABLE III.

LIST OF *INVESTIGATOR* DREDGING-STATIONS IN THE DEPTHS OF THE ARABIAN SEA.

| Serial No. of Station. | Date. | North Latitude. | East Longitude. | Depth in Fathoms. | Corrected Bottom Temp. Fahr. | Surface Temp. Fahr. | Nature of Bottom. |
|---|---|---|---|---|---|---|---|
| 2 | 5.5.86 | 6° 32′ | 79° 37′ | 675 | ... | ... | Green mud and Baryta nodules. |
| 104 | 3.5.90 | 14° 12′ 47″ | 74° 25′ 30″ | 1000 | 38°.6 | 83° | Olive green mud, with 2¼ per cent. of foraminifera shells. |
| 105 | 5.5.90 | 15° 2′ | 72° 34′ | 740 | 44° | 83° | Grey ooze, with 12 per cent. of foraminifera shells. |
| 106 | 22.10.90 | 9° 53′ 34″ | 75° 16′ 30″ | 1091 | 37°.5 | 83°.5 | Green mud, about 3 per cent. of foraminifera shells. |
| 107 | 23.10.90 | 8° 23′ | 75° 47′ | 738 | 41°.9 | 79°.5 | Green mud. |
| 108 | 24.10.90 | 7° 4′ | 76° 34′ 15″ | 1043 | 38° | 80° | Green mud, with foraminifera. |
| 109 | 25.10.90 | 7° 41′ | 78° 21′ | 738 | 42° | 81° | Green mud. |
| 121 | 22.10.91 | 14° 35′ 15″ | 72° 2′ 37″ | 1140 | 37°.5 | 85°.5 | Grey calcareous ooze (coral mud). |
| 122 | 29.10.91 | 12° 5′ 35″ | 71° 35′ 50″ | 865-880 | 40° | 77° | Globigerina-ooze. |
| 124 | 21.11.91 | 10° 47′ 45″ | 72° 40′ 20″ | 703 | ... | ... | Large water-worn fragments of reef-coral. |
| 125 | 3.12.91 | 10° 7′ 50″ | 74° 42′ 30″ | 1250 | 36° | 83° | Blue mud. |
| 126 | 4.12.91 | 8° 49′ | 73° 18′ 45″ | 1370 | 36° | 85° | Grey calcareous ooze (coral mud). |
| 127 | 12.12.91 | Off Minnikoy | ... | 1200 | ... | ... | Grey calcareous ooze (coral and foraminiferal). |
| 128 | 14.12.91 | 6° 58′ | 77° 26′ 50″ | 902 | ... | ... | Green mud. |
| 135 | 4.5.92 | 15° 29′ | 72° 41′ | 559 | 47° | 83° | Green mud, with foraminifera. |
| 136 | 4.5.92 | 15° 41′ | 72° 43′ | 444 | 48°.9 | 82° | Green mud, with foraminifera. |
| 144 | 19.10.93 | 15° 5′ 6″ | 72° 48′ 10″ | 172 | ... | ... | Sand. |
| 14[illegible] | 19.10.93 | 15° 5′ 3″ | 72° 38′ 10″ | 696 | ... | ... | Green ooze. |
| 150 | 29.11.93 | 7° 5′ 45″ | 75° 4′ | 719 | ... | ... | Fine coral sand. |

TABLE III.—*Continued.*

| Serial No. of Station. | Date. | North Latitude. | East Longitude. | Depth in Fathoms. | Corrected Bottom Temp. Fahr. | Surface Temp. Fahr. | Nature of Bottom. |
|---|---|---|---|---|---|---|---|
| 151 | 4.12.93 | Colombo Lighthouse, S. 64 E. 13½ miles | | 142-400 | ... | ... | Brown mud. |
| 176 | 4.5.94 | 11° 47′ 6″ | 73° 57′ 30″ | 1070 | 37°.5 | 84° | Green mud. |
| 177 | 5.5.94 | 13° 47′ 49″ | 73° 7′ | 636 | 44°.2 | 85°.5 | Green mud. |
| 178 | 20.10.94 | 23° 4′ 54″ | 66° 48′ 15″ | 210-170 | 64°-61°.7 | 82°.5 | Mud. |
| 183 | 1.1.95 | 23° 8′ 22″ | 65° 49′ 45″ | 890 | 40°.5 | 72° | Soft grey mud. |
| 184 | 2.1.95 | 22° 14′ 25″ | 67° 8′ 55″ | 947 | 40°.5 | 75°.5 | Grey mud. |
| 185 | 2.1.95 | 22° 25′ | 67° 17′ 45″ | 457 | 50°.5 | 74°.5 | Grey clay. |
| 187 | 3.1.95 | 21° 20′ 51″ | 68° 8′ 9″ | 113 | 64°.2 | 74°.5 | Green mud. |
| 188 | 3.1.95 | 21° 22′ 15″ | 68° 0′ 55″ | 155 | 61° | 76° | ... |
| 190 | 4.1.95 | 20° 38′ 50″ | 69° 17′ | 108 | 67°.7 | 72°.5 | ... |
| 191 | 13.1.95 | 16° 15′ 30″ | 72° 22′ 3″ | 112 | 62° | 80°.5 | ... |
| 192 | 14.1.95 | 15° 11′ | 72° 28′ 45″ | 912-931 | 40°.2-39°.5 | 80°.7-81° | Grey ooze. |
| 194 | 15.1.95 | 13° 47′ | 72° 3′ 45″ | 891 | 41° | 81° | Soft grey ooze. |
| 196 | 16.1.95 | 12° 54′ 30″ | 72° 22′ | 484 | 48°.2 | 81° | Grey ooze and foraminifera. |
| 197 | 20.1.95 | 9° 34′ 57″ | 75° 36′ 30″ | 406 | 48° | 81°.8 | Green mud. |
| 204 | 19.4.95 | 6° 50′ 20″ | 79° 36′ 20″ | 180-217 | 53° | 84°.8 | Broken coral. |
| 211 | 21.2.96 | 23° | 66° 8′ | 609-620 | 46°.5 | ... | Grey mud. |
| 212 | 22.2.96 | 21° 43′ 45″ | 68° | 111 | 63°.5 | ... | Pteropod-ooze. |
| 213 | 22.2.96 | 11° 25′ | 68° 2′ 30″ | 137-131 | 61°.7 | ... | Mud and foraminifera. |
| 216 | 19.10.96 | 6° 55′ 18″ | 72° 51′ 30″ | 767-950 | 41° | 81°.5 | Grey ooze. |
| 217 | 21.10.96 | 6° 56′ 56″ | 72° 53′ 30″ | 459 | ... | 82° | Sand. |
| 218 | 21.10.96 | 6° 55′ 6″ | 72° 55′ | 210 | 52° | 82° | Sand. |
| 219 | 24.10.96 | 6° 59′ 30″ | 79° 33′ 30″ | 531 | 45° | 83° | Green mud. |
| 229 | 16.10.97 | 9° 29′ 34″ | 75° 38′ | 360 | 48°.5 | 82° | Green mud. |
| 230 | 18.10.97 | 7° 40′ | 76° 0′ 52″ | 824 | 40° | 81°.5 | Green mud and sand. |

TABLE III.—*Continued.*

| Serial No. of Station. | Date. | North Latitude. | East Longitude. | Depth in Fathoms. | Corrected Bottom Temp. Fahr. | Surface Temp. Fahr. | Nature of Bottom. |
|---|---|---|---|---|---|---|---|
| 231 | 18.10.97 | 7° 34′ 30″ | 76° 8′ 23″ | 836 | 40° | 82° | Green mud and sand. |
| 232 | 19.10.97 | 7° 17′ 30″ | 76° 54′ 30″ | 430 | 38° | 82° | Grey mud. |
| 243 | 12.10.98 | 16° 12′ 45″ | 72° 4′ | 249-528 | 54°-48° | ... | Stones and green mud. |
| 244 | 13.10.98 | 14° 31′ 15″ | 73° 10′ | 124-119 | ... | ... | ... |
| 245 | 14.10.98 | 12° 40′ 28″ | 74° 2′ 45″ | 449-465 | ... | ... | Green mud. |
| 246 | 15.10.98 | 11° 14′ 30″ | 74° 57′ 15″ | 68-148 | 67°.5 | ... | Sand and stones. |
| 248 | 17.10.98 | 8° 37′ | 75° 37′ 30″ | 224-284 | 54°-52° | 84° | Sand. |
| 249 | 18.10.98 | 7° | 76° 36′ 15″ | 1022 | 37° | 81° | Green mud and foraminifera. |
| 250 | 20.10.98 | 6° 54′ 30″ | 79° 34′ 30″ | 480 | 46°.5 | 81° | Green mud. |
| 256 | 21.4.99 | 7° 58′ | 79° 23′ | 937 | 39°.5 | ... | Green mud. |
| 257 | 22.4.99 | 7° 15′ | 77° 46′ | 143 | ... | ... | Sand. |
| 258 | 23.4.99 | 8° 23′ | 76° 28′ | 102 | ... | ... | Sand. |
| 259 | 17.1.00 | 10° 9′ 43″ | 75° 33′ 30″ | 295-360 | ... | ... | Green mud and sand. |
| 260 | 18.1.00 | 8° 28′ 15″ | 76° 7′ | 487 | ... | ... | Green mud and foraminifera. |
| 261 | 18.1.00 | 8° 10′ | 76° 26′ | 445-386 | ... | ... | Green mud and sand. |
| 267 | 9.4.00 | 7° 2′ 30″ | 79° 36′ | 457-589 | ... | ... | Green mud and sand. |
| 268 | 10.4.00 | 7° 36′ | 78° 5′ | 595-556 | ... | ... | Green mud and sand. |
| 269 | 11.4.00 | 8° 9′ | 76° 30′ | 464 | ... | ... | Green mud and sand. |
| 270 | 12.4.00 | 9° 47′ 30″ | 75° 32′ | 589-564 | ... | ... | Green mud and sand. |
| 272 | 27.12.00 | 12° 41′ 45″ | 73° 40′ 30″ | 902 | ... | ... | Green mud and foraminifera. |
| 273 | 27.12.00 | 12 47′ | 73° 44′ 45″ | 870-823 | ... | ... | Green mud and sand. |
| 274 | 3.1.01 | 10° 33′ | 74° 45′ 15″ | 1150-1170 | 35° | ... | Green mud. |
| 275 | 4.1.01 | 8° 27′ | 75° 35′ | 771-731 | ... | ... | Green mud. |
| 276 | 5.1.01 | 7° 11′ | 76° 35′ 30″ | 1005 | 35°+ (?) | ... | Green mud. |

# APPENDIX B.—BIBLIOGRAPHY OF THE *INVESTIGATOR*.

THE movements of the *Investigator* and the progress of her survey work are officially recorded in the annual *Administration Reports of the Marine Survey of India* subsequent to the year 1881: in these Reports are also to be found occasional brief notices of the results of her zoological explorations.

More detailed accounts of her zoological observations have appeared in an unofficial series of *Natural History Notes from H.M. Indian Marine Survey Ship "Investigator,"* the constituent parts of which have been published in various scientific journals, but chiefly in the *Journal of the Asiatic Society of Bengal* since the year 1885, and in the *Annals and Magazine of Natural History* since the year 1889. This series was proposed by the late Professor J. Wood-Mason, and was initiated by Dr G. M. J. Giles, I.M.S., who was Surgeon-Naturalist to the Marine Survey from 1884-1888.

In 1892 the Government of India sanctioned the publication of twelve quarto plates of photo-etchings, to illustrate some of the new species of deep-sea animals described in the *Natural History Notes*. This subsequently became an annual publication, under the title of *Illustrations of the Zoology of the Royal Indian Marine Survey Ship "Investigator,"* issued under the authority of the Director of the Royal Indian Marine.

More recently an official series of Deep-sea Monographs, in which the revised contents of all the earlier reports are embodied, has been commenced. The cost of this series has, so far, been borne by the Indian Museum, in which institution all the *Investigator* collections have been deposited.

The following is a complete list, arranged according to subject, of all the *Investigator* publications outside the Annual Reports of the Marine Survey:—

## *A.*—ZOOLOGY.

### I. General Zoology.

J. Wood-Mason, A. Alcock, A. R. S. Anderson, A. F. M'Ardle—*Illustrations of the Zoology of the Royal Indian Marine Survey Ship "Investigator."*—(Published under the authority of Rear-Admiral Sir John Hext, R.N., K.C.I.E., Director of the Royal Indian Marine; and afterwards of Captain W. S. Goodridge, R.N., C.I.E., Director of the Royal Indian Marine; Calcutta, 1892, and 1894-1901.)—Echinoderma, plates i.-v.; Crustacea, plates i.-lv.; Mollusca, plates i.-xiii.; Fishes, plates i.-xxxv. (In progress.)

A. Alcock—"Deep-sea Life in the Bay of Bengal" (extracts from a lecture delivered before the Microscopical Society of Calcutta), *Journal of the Bombay Natural History Society*, vol. viii., 1893-94, pp. 545-550. (Reprint from the *Bulletin of the Microscopical Society of Calcutta*, for September 1893.)

A. Alcock—*A Summary of the Deep-sea Zoological Work of the Royal Indian Marine Survey Ship "Investigator" from 1884 to 1897*; Scientific Memoirs by Medical Officers of the Army of India, pt. 11, 1899, pp. 1-49. (Contains a brief outline of the origin and progress of marine surveying in India.)

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### II. Protozoa.

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J. WOOD-MASON and A. ALCOCK—*Annals and Magazine of Natural History*, January 1891, p. 3; and December 1891, pp. 451, 452, fig. 16—General Notes. Description of a New Species of Hormosina.

F. CHAPMAN—"On some Foraminifera obtained by the *Investigator* from the Arabian Sea," *Proceedings of the Zoological Society*, 1895, pp. 4-55, plate i. (*A few new species and varieties are described and figured.*)

### III. PORIFERA.

F. E. SCHULZE—"Hexactinelliden des Indischen Oceanes," *Abhandlungen der königl. Preuss. Akademie der Wissenschaften zu Berlin*, 1894, pp. 1-60, taf. i.-ix., "Die Hyalonematiden;" and 1895, pp. 1-92, taf. i.-viii., "Die Hexasterophora;" and 1900, pp. 1-46, taf. i.-vii.

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### IV. COELENTERA.

J. ARMSTRONG—"Hydroid Zoophytes from the Indian Coasts and Seas," *Journal, Asiatic Society of Bengal*, vol. xlviii., pt. 2, 1879, pp. 98-103, plates ix.-xii. (*pre-"Investigator" paper*).

J. WOOD-MASON and A. ALCOCK—*Annals and Magazine of Natural History*, January 1891, pp. 4-8; and December 1891, pp. 449-451, fig. 15—Deep-sea Corals.

A. ALCOCK—"On Some Newly-recorded Corals from the Indian Seas," *Journal, Asiatic Society of Bengal*, vol. lxii., pt. 2, 1893, pp. 138-149, plate v.

A. ALCOCK—"On Some Actiniaria from the Indian Seas," *Journal, Asiatic Society of Bengal*, vol. lxii., pt. 2, 1893, pp. 151-153.

A. ALCOCK—*Journal, Asiatic Society of Bengal*, vol. lxii., pt. 2, 1893, pp. 169-171, Actiniaria and Corals, plate viii., figs. 1, 2.

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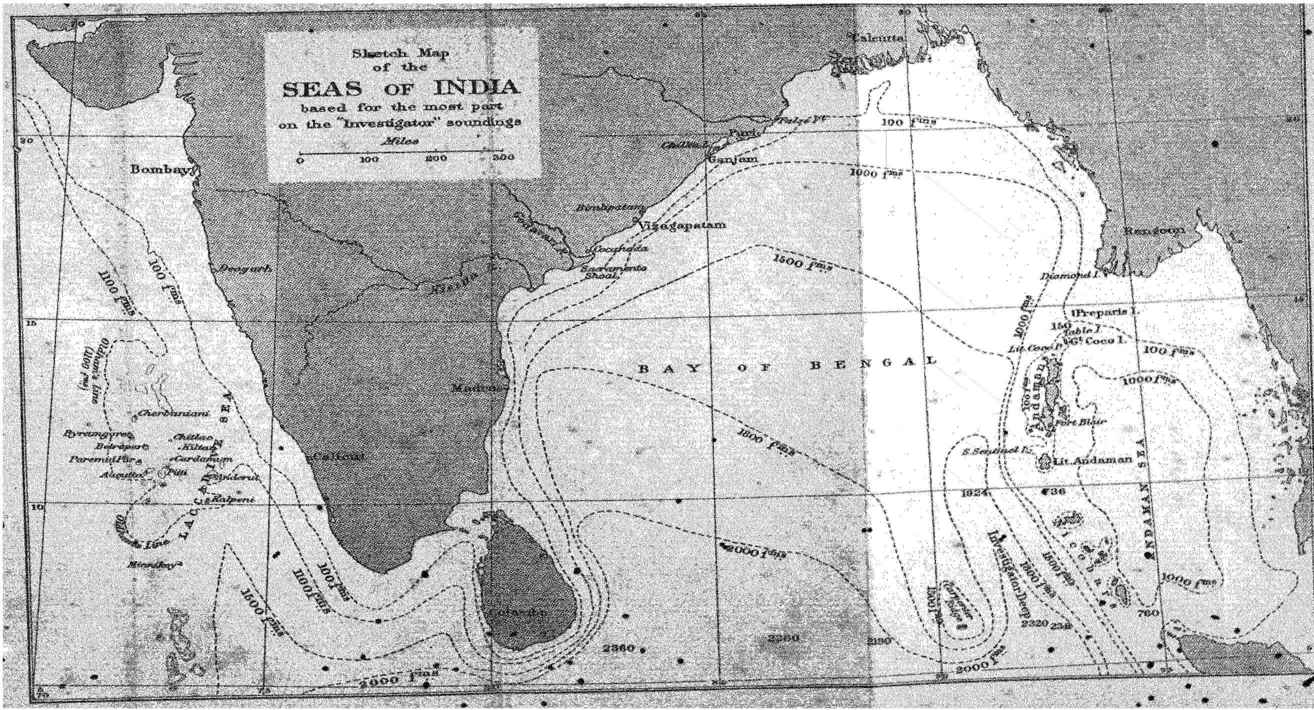

Sketch Map
of the
SEAS OF INDIA
based for the most part
on the "Investigator" soundings
Miles
0 100 200 300
Bombay
Calcutta
Puri
Ganjam
Vizagapatam
Cocanada
Sacramento Shoal
Madras
Rangoon
BAY OF BENGAL
ANDAMAN SEA
LACCADIVE SEA
Diamond I.
Preparis I.
Gt. Coco I.
Lit. Andaman
Port Blair
S. Sentinel I.
Investigator Deep
Carpenter Ridge
Oldham's line (1100 fms)
Cherbaniani
Kiltan
Cardamum
Kalpeni
Minnikoy
100 fms
1000 fms
1100 fms
1500 fms
1800 fms
2000 fms
2360
2320
1924
736
700

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